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Construction of a textbook in mechanical drawing based upon the principles of learning

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THE CONSTRUCTION OF A TEXT BOOK IN MECHANICAL DRAWING BASED UPON THE PRINCIPLES OF LEARNING

by

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Note

This copy is incomplete in that it contains no illustrations nor plates for the drawings. Refer to the library for complete copy.

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Preface

It would seem that the field of text books for mechanical drawing had been amply covered by the many books offered on this subject. Yet during ten years of experience in the teaching of this subject the author has not seen one that presented material in a psychological order and made use of sound principles of learning. The material has been presented chiefly in an order such as a draftsman would use in making a drawing or in an order of progression of problem difficulty or as a reference book wherein one may find material for the making of a drawing. It is doubtful whether any of these texts prepared by these methods would stand a scientific analysis. They lack the application of the principles of learning which the modern conception of educational efficiency demands. This belief has urged the author to make a study of the two-fold problem, namely:

(1) The analysis of existing texts.

(2) The writing of a text that would meet sound criteria essential for an elementary text book in mechanical drawing.

In approaching the first problem all text analyzed were subjected to an examination by the author. The analysis was limited to content only and did not include physical structure. After certain standards were established,

each text was studied to determine to what extent the criteria were fulfilled.

The rating of texts has been used as the introduction to the second or major problem of writing a text that will satisfy the modern principles of education in the field of vocational training.

Introduction

Criteria of a Good Text Book

Twelve criteria have been set up covering the essentials of a good mechanical drawing text book. The reason for the establishment of each criterion, why it is essential that a text should meet this requirement, and the advantages of meeting the requirement or the disadvantages of not meeting the requirement follow in each case the statement of the criterion.

Criterion 1. The text should be based upon psychological order.

The method, usually followed in the drafting room, of having the student complete each drawing in turn is the procedure developed from commercial practice where experienced draftsmen make complete drawings. This is the logical order for a commercial drawing and therefore may be called the logical teaching order, but, from the learner's viewpoint and for good educational method it is not sound. Instead of treating each drawing as a unit the psychological order would require, rather, the independent treatment of the component parts which collectively constitute a drawing.

Criterion 2. The text should provide good pedagogical procedure.

The method of presenting the material must be such that it may be easily understood by the student; should convey the necessary information while being thought provoking; should secure the desired results in construction and technique without the formation on the student's part of habits that are detrimental to later progress.

Criterion 3. The text should be divided into units of work.

To offset the artificial conditions of school training, to secure for the student the beneficial sense of having accomplished a definite piece of work, and to assist in the teacher's determination of accomplishment the text should be divided into units of work. This also makes possible the teaching of certain definite units of the subject of drafting such as pencil drawing, or lettering without the necessity of the student going through other constructive work not needed to secure the particular accomplishment desired. For night and trade school work such a division into units is necessary if the training is to be considered efficient.

Criterion 4. The text should develop technique.

It is absolutely essential that the commercial drawing should have good technique in order that no possible opportunity for a difference of interpretation may be present. Unless examples or standards of good technique

are set up and provided from the very beginning, the student will develop his own unfavorable habits and techniques. He must possess good technique before his drawings will have commercial value. It is easier to establish good habits in the beginning than to do the double task of removing old habits and then establishing new ones.

Criterion 5. The text should provide practical problems.

Is it necessary that the student shall learn such principles of drawing as projection and intersection on theoretic and imaginative problems and then be required in the commercial world to make his own transfer from theory to practice? If an imaginary problem has no practical application, why should it be taught? If it has an application, why not teach the applied in the first place? From this viewpoint it would seem a waste of time to teach drawing by means of artifidal projects when the same principles of drawing can be taught through projects that have practical application.

Criterion 6. The text should be considerate of the learner's time.

Too much repetition of procedure without the introduction of new processes or new applications of old principles is waste of the learner's time.

Criterion 7. The text should be self-sufficient.

All the material and information necessary to enable the pupil to successfully master the problems should be contained in the text. The material should be presented by examples and illustrations, by reference to preceding work or by discussion of the topic to be treated. Reference to other books should not be necessary, though the broader the sources of information, the more intelligently the worker can attack his problem. For night school and home work other references are often not available.

Criterion 8. The text should not be a copy book but develop an understanding of procedure.

Discussion of this phase of the text would hardly seem necessary but frequently texts of the copy book type have been made. This type of text does develop the manual skill of the worker but does little for his understanding of procedure and little to develop the ability to apply his skill and learning to new problems.

Criterion 9. The text should develop each phase of drafting separately.

As every teacher of drafting knows, this subject has long been likened to a language and just as some idea is expressed through language in a book with its divisions and sub-divisions of chapters, paragraphs, sentences, words, and letters, so a drafting problem consists of several means of conveying the desired information. And similarly

as the written language is studied by developing an understanding of the component parts, so should the parts of drafting be studied. The larger divisions of drawing are probably determination of views and position, penciling, dimensioning, lettering, inking, and tracing. Each of these larger divisions has in turn many smaller divisions. Penciling might be taken as an example, with the horizontal line, the vertical line, the invisible edge line, construction line, projection lines and the intersection of lines of each of these types. To the person capable of reading a drawing, each of these kinds of lines has a distinct meaning and any confusion in their use by the draftsman would make possible the misinterpretation of that portion of the drawing. With such a complexity of means of expression, can it be expected that the student will learn their use when presented to him in a confused order and mixed with new information from other major divisions?

Criterion 10. The text should develop each phase of drafting in psychological order.

It is not enough that each phase of drafting should be developed separately as previously discussed, but each phase must be developed psychologically. Imagine the confusion that must be in the student's mind when he is required to make a drawing for the first time which contains the expression of intersecting invisible edges, terminal

invisible edges, crosshatching of two or three materials, dimensioning of circular objects, and oblique dimension lines. Material must be thoroughly assimilated by the pupil before going on.

Criterion 11. The text should provide uniform introduction of new material.

When a text is developed on a psychological basis, new material should be presented in such a manner as to make the assimilation of new material, information and skill a continued and even process. Too many new concepts to be formed in close relation to each other will tend to be confusing while too few or none at all is a waste of the learner's time.

Criterion 12. The text should teach commercial practices.

Drafting is a commercial trade subject whose value is in its use. To be most useful the text must adhere to the practices and procedures as followed by the commercial drafting room.

The Rating of Mechanical Drawing Text Books Now or Recently in Use

It was desired to find to what extent text books on drafting now or recently in use fulfill the twelve criteria that were set up. For this purpose a sampling of text books that have been published during the past several years was

taken. No effort was made to select texts having any particular method of treatment of the subject. The only requirement was that they treat with drafting for beginners. A total of eleven texts were rated with respect to the twelve criteria. The following pages contain an annotated bibliography of those texts that were rated, the procedure for rating, the table of ratings, and the conclusions drawn from the table.

Annotated Bibliography of Texts Rated

A. Essentials of Drafting, Svensen, 1925.

A combined handbook and text book for elementary mechanical drawing: divided into chapters each dealing with a separate topic such as lettering, construction, materials, threads and machine construction. The last third of the book is given to the statement of problems based on the degree of complexity.

B. I.C.S. Reference Library, Vol. 33.

Deals with structural drafting and geometric drawing. A text containing specific problems tending to develop technique and drafting practice rather than knowledge of drafting principles.

C. Mechanical Drawing for Secondary Schools, Crawshaw and Phillips, 1916.

A foundational text covering sketching, pencil drawing, tracing, blueprinting, sheetmetal, machine drawing, wood-

work, measurements, architecture, isometric and cabinet drawing. The divisions on sheetmetal and architecture were called advanced, but were of secondary school difficulty.

D. Mechanical Drawing for Secondary Schools, French and Svenson, 1919.

A reference book rather than a text; contains brief points on how to draw, lettering, theory of projection, principles of size description, bolts and threads, sections, brief description of types of drawing, construction and sheet metal. About one third of the book is given to the statement of problems.

E. Elements of Machine Drawing, Jamison, 1904.

A text book containing information relative to elementary principles and definitions, lettering, projection, drawing tools, methods of reproducing drawings, gearing, sketching and mechanical execution of drawings. A series of plates are given under the separate sections which the pupil shall copy.

F. Advanced Machine Drawing, Jamison, 1905.

A text book dealing with isometric drawing, shadows, perspective, theoretical problems and a few practical problems. Discussion and problems are mostly theoretical.

G. Mechanical Drawing, Kenison, 1912, American School of Correspondence.

A text book dealing principally with construction and

intersections; contains few drawing plates. There is considerable discussion of each.

H. Engineering Drawing Theory and Application, Kerekes, 1928.

A text book suitable for pupils of advanced age or ability of comprehension; deals briefly with projection and working drawings of machine nature. Over one half of the book is devoted to sheetmetal. There is a small section on lettering and construction.

I. Machine Drawing for Trade Schools, C. C. Leeds, 1911.

A text or copy book on machine and sheetmetal drawing. It is not a trade school text for drawing but limited to copying and tracing and contains little information.

J. Mechanical Drawing, John S. Reid, 1919.

A text or manual suited to pupils of advanced age or ability; contains information on the use of instruments, construction, lettering, projection, working drawings and shadows. Problems are of a theoretic nature.

K. Engineering Drawing, French, 1920.

Primarily a handbook on general mechanical drawing suitable to pupils of advanced high school or college grade; material is grouped by types, treats of projection, sketching, use of instruments, machine drawing, structural drawing, architecture, patent drawing and mapping. Each type is followed by statements of a number of problems.

Procedure for Rating

All texts were carefully studied. Each was examined and rated with respect to each separate criterion. The ratings were determined wholly by the judgment of the author. The rating for each criterion was done on the basis of ten points where the criterion was fully met and a rating ascribed between ten and zero in proportion to the degree in which the text met the criterion. The table on the following page gives the results of the rating of these eleven mechanical drawing texts or hand books.

Each number at the top of the table refers to the criterion with the corresponding number.

The alphabetical index refers to the text so lettered in the annotated bibliography.

The totals as found at the end of the horizontal lines give the cumulative rating for the respective texts. This column should not be considered as a final rating or as an accurate index of the value of the text for it will be noted that equal values have been given to each criterion. Undoubtedly they are not of equal value. The result, however, would probably be no nearer a true rating if varying values had been ascribed to the different criteria as these values in turn could only be determined arbitrarily by the author.

The final rating as given in the column headed 'rating'

is based on the totals by giving a rating of (1) to the text having the highest total, (2) to the second highest, and continuing thus through the column for the eleven texts.

Table of Text Ratings

text letter	criterion number												total	rating
	1	2	3	4	5	6	7	8	9	10	11	12		
A	2	4	0	0	10	8	8	10	5	8	0	8	80	3
B	5	4	5	8	5	8	8	2	5	8	0	8	66	2
C	0	5	10	8	8	8	5	8	8	5	0	5	70	1
D	0	0	0	0	5	5	5	8	5	5	0	0	33	6
E	0	0	2	8	0	5	8	0	0	0	0	2	25	9
F	0	2	2	5	8	8	5	2	5	5	3	0	28	8
G	0	5	0	0	0	5	8	2	5	5	0	0	30	7
H	5	5	5	0	8	5	5	10	0	0	5	0	48	5
I	0	0	0	8	0	5	5	0	0	0	0	0	18	11
J	0	0	0	0	2	5	5	8	0	0	0	0	20	10
K	5	5	8	2	8	8	5	10	0	0	0	8	59	4
cases	4	7	6	6	8	11	11	9	6	8	8	5	average	7
zero scores	7	4	5	5	3	0	0	2	5	5	9	6		

Conclusions Drawn from the Table

With twelve criteria and a perfect score of ten points for each, the perfect score for a single book would be one hundred and twenty points. As will be noted from the table, the highest score received by any book examined was seventy or just a little more than half of what should be expected.

Only four books received a score of approximately fifty per cent of the full score, the others being rated much lower. It is evident that the construction of a text book for mechanical drawing which will more nearly meet the criteria established is a greatly needed undertaking for the advancement of this part of industrial vocational education.

That the criteria set up are fundamentally sound is brought out by the uniform spread of scores throughout the table. There was no criterion that had not been considered in less than two books and the average number of times was seven.

The large number of times a zero score was recorded would seem to be indicative of a lack of the scientific study of mechanical drawing and of the failure of text book authors to plan their book for the best educational procedure.

FOUNDATIONAL TEXT BOOK

in

MECHANICAL DRAWING

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To show how to make blueprints.

Preface

In constructing the mechanical drawing text that follows every effort has been made to do so as scientifically as possible, to follow the principles of learning, and to provide means of securing the desired abilities in drafting with the greatest economy of time and effort.

The material and procedure of this text were developed through a period of five years of experimentation in junior and senior high schools and in adult night schools. The results secured have exceeded those of other texts and methods. The technique of the pupils was better. Their ability to construct independently a drawing of commercial character was greatly improved. These results, however, were not determined by scientifically controlled groups but wholly by the author's observation.

This is an elementary text designed to provide the fundamental information and develop munipulative skills essential to advanced work in most of the distinctive types of drafting.

Its form of construction makes it suitable as a beginning course and text for junior high school grades, short term night schools, continuation schools, and part-time schools. It provides the related trade drafting for several trades, as well as being a beginning course and text for the

trade of drafting. The completeness of its content also makes it suitable as a "home study" text.

A radical change from the usual text book has been made in order to secure the desired procedures consistent with the principles of learning. This is most noticeable in the first ten plates, which are carried in rotation consecutively through the fundamentals of drafting for each different phase or division of drafting content. Each plate was designed or selected from theory and experimentation so as to provide just the material needed, but no foreign material, to carry out the development of learning appropriate at that particular time.

Twelve criteria were set up around which to build the text. These were:

1. The text should follow the psychological order.
2. It should provide good pedagogical procedure.
3. It should be divided into units of work.
4. It should develop technique.
5. It should provide practical problems.
6. It should be considerate of the learner's time.
7. It should be self-sufficient.
8. It should not be a copy book but develop an understanding of procedure.
9. It should develop each phase of drafting separately.
10. It should develop each phase of drafting in psycho-

logical order.

11. It should provide uniform introduction of new material.

12. It should teach commercial practices.

These criteria were met in this text as follows:

Criterion Number One was considered throughout the book and is specifically noticeable in the separate treatment of the component parts of a drawing.

Number Two: The form in which new material is presented and the type of information accompanying this introduction provides good pedagogical procedure.

Number Three: This was provided for by division of the work into distinctive units. These units are a natural division under the form of the text and not an arbitrary division of a given number of hours.

Number Four: The establishment of definite standards of technique, the uniform introduction of new material and the omission of unnecessary repetition are conducive to good technique.

Number Five: Every project was made a practical one taken from inudstry. In the division of lettering a few exercises have been used to facilitate learning.

Number Six: Each plate was selected to provide specific experiences without unnecessary repetition of old material. Helpful suggestions have been given where needed and pro-

cedures provided where such were advisable.

Number Seven: All information, directions, and illustrations needed for the carrying out of the course are contained in this text.

Number Eight: Plates are presented in another form than that in which the pupil is to make the drawing. The isometric method is used in most cases.

Number Nine: For psychological reasons each unit or phase was developed by progression through the successive plates, only one phase being treated at a time.

Number Ten: This criterion is closely related to Number Nine and was provided for through the same means as used in Number Nine.

Number Eleven: Great care was used in the selection of plates to be drawn to see that the new material presented in each was as nearly quantitatively equal as possible. Reference to the "Table of Purposes" will show this fact.

Number Twelve: Commercial methods of representation, abbreviation, and of symbolization have been used.

CHAPTER I

DIVISION OF GENERAL INSTRUCTION

GENERAL INSTRUCTIONS

These general instructions should be carefully read and observed both by the student who is going to make the drawings and by the instructor in charge of the work if the text is being used as a class text. There is no item too small or of so little importance that it should be omitted. Every plate contains some new information requiring additional skill and technique for its execution, and for this reason no plate should be omitted.

Mechanical drawing is a universal language and when properly made is readable by those of any nationality who have studied that language. Each kind of line, each group of lines, the signs and symbols used, the arrangement or position on the sheet of the views, the dimensions, their position and grouping, these and all other facts and points of technique are parts of the language of mechanical drawing. The road to the successful making of a mechanical drawing is by the observance of all the rules and methods that go into the making of a drawing. Good technique is absolutely essential for a commercial drawing and should be worked for by the student with the greatest effort possible; speed will come with the development of skill in manipulative ability and with the growth of the knowledge of mechanical drawing, but technique can be acquired only by great care and effort.

Each plate should show an increased knowledge and application of technique, the fine points, the distinctive points, of a drawing that set it off from the carelessly made drawing. It is attention to these details which makes it possible to read the drawing without liability of double or misinterpretation.

When we board a train and it pulls out of the station, we know its destination and have taken that particular train because it will take us to a definite place to which we want to go; so, likewise, let us make a brief survey of the mechanical drawing course herein contained that we may know the route to be followed and the objective to be worked for.

The first ten plates contain the fundamentals of simple machine drawing, dealing with position of views, line values and line meanings, the use of tools necessary for common drawings, how to draw from one view to another, the way to show the inside of an object and the kind of material of which it is made, how to draw views that do not come in the regular position, and last, how to show if there are to be threads on the work. These first ten plates are to be drawn in pencil only, and will contain no dimensions or lettering. They are made just to show how the drawing of the object alone is to be made. This completes the first group or unit of work.

Starting with the first drawing again and working through

the ten drawings in their consecutive order, the objects shall be inked in. The proper weights and kinds of lines shall be used and the care and use of the inking tools observed. This completes the second group or unit of work.

A drawing that is inked is still of no value, for the purpose of a mechanical drawing is to present the idea of an object that is to be made to some other person so that he may make that object. It is easily seen that in order to do this the drawing must also give the dimensions that are necessary to insure the object being made as designed by the draftsman. For this purpose it is necessary to return to Plate One and put on the dimensions of the object. The remaining nine plates shall also be dimensioned in their consecutive order. This completes another mile stone on our road and the third group or unit of work.

After a few short exercises in which are shown the shape and spacing of letters we return once more to the first plate made and put on the lettering necessary for that plate. The following nine plates shall likewise be lettered in. All ten plates shall be lettered in pencil first and then starting with the first once more and continuing in their consecutive order the lettering shall be inked in. This completes the fourth unit of work. The first ten drawings are now done and may be considered complete working drawings.

The fifth unit of work is to make one or more assembly

drawings from the information contained on the detail working drawings provided. This unit gives practice in reading a drawing, develops visualization, and requires accuracy in measuring and drawing to make the various parts fit.

The sixth and last unit of this course is to make detailed drawings from dimensioned assembly, isometric or section drawings and brings into use all the information that has been presented in the course. The ability to make usable working drawings of machine parts that are not too complicated, involved, or requiring great technical knowledge of the subject treated is the direct objective of this course.

Tools and Materials Required

The following list of tools and materials is required to pursue the work of this course to the best advantage.

Drawing board:

The drawing board should be a three-ply bass wood board either with or without cleats on the back. An 18 x 24 inch board is recommended, though a board as small as 15 x 20 will do.

T-square:

The T-square should be 24" long with transparent edges. If the 15 x 20 drawing board is used, then an 18" T-square will be long enough.

Triangles:

There are two kinds of triangles used, namely, the 45

degree triangle and the 30-60 degree triangle. Both should be made of transparent material. A 7" 45 degree triangle and a 9" 30-60 degree triangle are recommended.

Scale:

The scale should be of the triangular form, made of box wood and divided with the proportional feet and inches as used by mechanical engineers. (This is the same as that used by architects). A 12" scale should be used.

Set of instruments:

A set of instruments should be selected that is as good as can be afforded by the student. Good instruments are more easily handled and enable the student to work more accurately with less bother and annoyance caused by cheap tool construction. The set should contain the following:

5 to 6 inch compass provided with pencil attachment, inking attachment and lengthening bar.

5 to 6 inch dividers, one leg being provided with a hairspring adjustment.

3 to 3½ inch spring bow dividers.

3 to 3½ inch spring bow pencil compass.

3 to 3½ inch spring bow inking pen.

A medium size ruling pen.

It is recommended that the best ruling pen possible be procured as it is almost impossible to do good inking with a poorly shaped pen. The plain ruling pen without devices for rapid opening and resetting for cleaning purposes is rec-

commended.

Pencils:

One 6H pencil for line work. One 1H pencil for lettering.

Paper:

Two sizes of paper shall be used, one size that will be known as a single sheet will be 10" x 13½", and the other will be known as a double sheet and will be 13½" x 20". A good grade of heavy, durable paper should be used--a paper that will stand considerable hard erasing without spoiling its texture, that will take ink easily without spreading. A white paper is preferable.

The number of sheets that will be required are:

2 sheets 13½ x 20 24 sheets 10 x 13½

12 sheets tracing paper or tracing cloth 10 x 13½

Thumb tacks:

One dozen thumb tacks.

Pen holder:

One plain cork tipped writing pen holder.

Pen points:

One ball point pen #516F by D. Leonardt & Company, one Esterbrook pen point #621 or 702, and one pen point #303 by Joseph Gillotts. Any other pen points giving lines of equal weight to these named will do as well.

India ink:

One bottle of Higgins black waterproof India drafting ink, or any ink of equal quality.

Erasers:

Art gum 1" x 2", pencil eraser, ink eraser.

Erasing shield:

A thin erasing shield with small openings.

Irregular curve:

One 8" transparent irregular curve commonly called a French curve.

Pen wiper:

A pen wiper of lintless cloth or a piece of thin chamois skin. The wrapper of the bottle of Higgins ink contains a good pen wiper.

Blotter:

Several pieces of ordinary blotting paper about 4 x 4.

Sand paper:

One dozen strips of #½ sand paper about ½" x 4". These strips can be made by cutting an ordinary size sheet of sand paper to the desired size.

Use of Instruments

T-square:

The T-square should be used on the left edge of the drawing board with the board turned in such a way that the blade

of the T-square is pointing in the direction of the longest dimension of the board. It should seldom be removed from the board and should never be used on any other edge of the board. It is sometimes used as a straight edge to connect two points that are far apart and that do not make any of the angles found with the triangles. The T-square should be moved with the left hand only, being sure to hold the head of the T-square tight against the board. See Figure 1. Do not move the T-square with the right hand or by taking hold of the end of the blade. Be careful never to knock the T-square in such a way as to loosen the head or to make nicks in the edge of the blade, as each nick will make a jog in any line that is drawn thereafter along that edge. The T-square is used more than any other one tool except the pencil, and should be kept in perfect condition. All horizontal lines are drawn along the top edge of the T-square.

Triangles:

An angle is the rate at which two lines are separating, not a distance that is measured in feet and inches. The angle near the point of intersection of two straight lines is the same as the angle which these same two lines make with each other at any other point along their length. The edges of a triangle represent the inclosing lines of the angles. The three edges of a triangle make possible three combinations of two lines, and so each triangle can be seen to have

three given angles. Angles are measured by degrees and the total angular distance around a circle is 360 degrees. By comparison and by trial it will be found that both triangles have one angle that is equal, and that this angle is equal to one-fourth of a circle and is therefore one-fourth of 360 degrees, or 90 degrees. One triangle has two angles that are equal, these being 45 degrees each. The other triangle has one angle of 30 degrees and the other angle of 60 degrees. See Figure 2. The triangle when in use should be held firmly against the top edge of the T-square while the latter is held rigidly in its proper position. The angle formed is the one that comes between the T-square and the edge of the triangle along which the line is drawn. The triangle should always be held in such a position that it lies under the hand that is drawing the line. Vertical and slanting lines are drawn with the use of the T-square and triangles. Figure 3 illustrates the use of the triangle.

Scale:

The ordinary scale in which the foot is divided into twelve inches is used for most drawings. When some other scale is used its method of use will be explained. Notice that the beginning of the scale or graduations for the scale is not at the end of the piece of wood, and measurements should be made from the first graduation and not from the end of the scale. The smallest divisions on this scale are six-

teenths of an inch. The scale is used for measuring purposes only, and should not be used as a guide along which to draw lines. In measuring, care must be used to see that the scale is held perpendicular to the line from which the measurement is to be taken.

Pencil:

A 6H pencil should be used for all line work as the marks made by this pencil will not smear when the T-square and triangles are passed over them. A 1H pencil is used for all free hand lettering, it being much easier to guide the soft pencil so as to make the desired shapes.

Pencils are graded for hardness. The grades are as follows: BB (2B), B, HB, HH (2H), HHH (3H), HHHH (4H), HHHHH (5H), HHHHHH (6H). Grades B and BB are free-hand drawing pencils. Grade HB is used for most common writing pencils. The grades H to 6H are used for mechanical drawing. There are softer and harder pencils than these made, but they are not in common use.

Sharpening the Pencil

The draftsman probably uses the pencil more than any other tool, and like the good mechanic in any trade, this tool should be of the best and should be kept in the best of working condition. It is therefore necessary to see that the pencil is correctly sharpened.

1. A long lead point is desirable. For this reason a jackknife should be used to sharpen the pencil rather than the common pencil sharpening machine. Start to remove the wood about one and three-eighths inches from the end opposite that on which the grade is marked. Gradually remove the wood until about three-eighths of an inch of lead is exposed. Do not sharpen the lead with the jackknife.

2. The lead is to be sharpened on a piece of sandpaper. Lay the strip of sandpaper on the edge of a board holding the ends of the paper down with the tips of the fingers. With the pencil in the right hand and held nearly in a horizontal position, draw the lead across the sandpaper and at the same time slowly rotate the pencil in a clockwise direction. Continue this action until the lead is brought to a long narrow point. A desirable pencil point is shown in Figure 4.

3. The lead should be frequently resharpened by using the sandpaper only. The wood need not be resharpened until the lead is down to about one-fourth of an inch in length. If the pencil is rotated slightly while drawing long lines the lead will retain its sharp point for a much longer time.

The use of other instruments will be explained at the time they are to be used.

The pencil lines on a drawing should be made very light. The object being drawn will be given the required darkness, that is, made to stand out clearly, when the drawing is inked

in. If much pressure is given to the pencil it will make an indentation in the paper which can never be removed. It is usually necessary to make several changes during the process of drawing and if the lines are made heavy they will be very hard or impossible to remove. A simple test to see if the lines are being made the right weight is to stand about ten feet from the drawing, at which distance the lines should be almost invisible.

Making the Border Lines

I. Purpose:

To prepare the paper for the drawing.

To show the use of the T-square, triangles and rule.

II. Tools required:

Drawing board, T-square, scale, and 30-60 degree triangles.

III. Supplies required:

One sheet 13½ x 10 drawing paper, 6H pencil, 4 thumb tacks.

IV. Instructions:

1. Hold the T-square in its proper position on the drawing board with the top edge of the blade about 5 inches from the bottom of the board.

2. Lay the paper on the board and then bring the paper down until it touches the top edge of the T-square. Now move

the paper to the left or right, as the case may require, until the left edge is about one and one-half inches from the left edge of the drawing board. The paper is placed near the left edge of the board so that the drawing will not be effected by the spring in the blade of the T-square.

3. Place the thumb tack in each corner of the paper so that the point of the tack is about one-fourth inch from the edge of the paper. To make the paper lie flat the tacks should be placed in the following order: Upper left hand corner, lower right hand corner, upper right hand corner, and last, lower left hand corner. Push the tacks all the way in. Refer to Figure 5.

4. Measure up one-half inch from the bottom of the paper near the center of the sheet and place one dot. Through this dot draw a horizontal line all the way across the paper. Hold the T-square in the correct position and draw this line along its top edge. Horizontal lines should start at their left end and be drawn toward the right. Figure 6 shows how to draw a horizontal line.

5. From the line just drawn, measure up 9 inches and place one dot. Through this dot draw a second line all the way across the paper in the same manner as for the first line.

6. Measure in one-half inch from the left hand edge of the paper near the center of the sheet and place one dot. Through this dot draw a vertical line the entire width of the

paper. Figure 7 shows how to draw a vertical line.

7. From the line just drawn measure to the right twelve and one-half inches and place one dot. Through this dot draw a second vertical line the entire width of the paper. This gives a drawing space of 12½ x 9 inches, the size required for all plates when a single sheet is used.

8. It is necessary to allow some space at the bottom of the paper for a title and other information that will be explained when the plates are lettered. For this purpose measure up from the bottom border line five-eighths of an inch and draw a line all the way across the paper. This same space is always to be allowed at the bottom of the sheet whether the paper is placed the long way or the short way across the board. The top line of the title space just made will hereafter be referred to as part of the border line and shall be drawn at the same time as the border line. Figure 8 shows a paper prepared with the correct border lines.

Position of Views

A mechanical drawing differs considerably from a pictorial drawing such as a photograph. The photograph shows just what would be seen when the object is looked at from one given spot. The mechanical drawing shows what would be seen if the eye of the observer were in front of or perpendicular to the surface that is being looked upon. In a photograph

not all parts are their true size in relation to the other parts; a house in the distance will be smaller in the photograph than one of the same size in the foreground of the picture. It appears in perspective. In a mechanical drawing all parts are drawn their exact size in relation to the other parts. For mechanical drawing if we look at an object from directly in front, it would be impossible to tell the thickness of that object. For this reason it is necessary to make more than one view to show all the facts about an object represented in mechanical drawing. Figure 9 represents an object drawn in a pictorial method and the same object drawn by orthographic projection, this being the name given to the kind of mechanical drawing we are studying.

If the student will perform the following exercise, he will see why each "view" comes in the position shown in Figure 9. Secure a piece of paper about 8½ x 11 inches (any kind will do).

1. Fold the paper lengthwise and crease in the middle. Open the paper out flat again.

2. Fold the paper crosswise and crease in the middle. Open out flat again.

3. With one of the long edges toward you, tear out the upper right quarter of the sheet on the creases just made.

4. Hold the paper up in front of you and fold the top

and right hand quarters back so as to form the corner of a box.

5. Mark the surface that is toward you "front", the top surface "top", and remaining surface "side". Figure 10 shows a paper thus folded and marked.

6. Now lay the paper out flat on the table and we have the names of the views of a drawing, and also the positions in which those views are always placed in relation to each other. The top view always comes directly above the front view. The right hand side view is the side that is usually drawn and will come to the right of the front view as this paper shows. If a left side view were to be made, as is sometimes necessary, this view would come to the left of the front view. When a bottom view is necessary it must be placed directly below the front view. When three views are required those shown by the paper are the ones to be made. A two view drawing may be either the top and front views or the front and side views. It should be noted that the position of the view on the paper will determine the name of the view rather than what may be the front, top, or side of the object being drawn.

An orthographic drawing is made as though the object were placed within the paper when folded like the box corner as just explained, and looked at through the paper from points perpendicularly to the front, top, and side respec-

tively. A surface is shown on a drawing by using lines to represent the edges that inclose the surface. Edges of an object are therefore shown on the drawing as solid lines. All visible edges of the object when looked at from the correct position must be represented on the drawing by a solid line. Figure 11 shows an object within the paper box and the way the three views are secure. Figure 12 shows the same paper laid out flat. The light lines between the views show that the side view is directly in a horizontal line with the front view and that the top view is in a position exactly vertical to the front view.

Spacing Views

The reputation of a draftsman, his standing as a good draftsman, is judged not only upon the correctness of the information the drawing contains, but to a great extent upon the appearance of the drawing. One of the factors that effect the appearance is the position of the different views on the drawing both in relation to each other and to their position on the paper. The drawing should be so placed that it will appear to be well centered on the sheet; the spaces surrounding views and that between the views and the border shall appear in balance. To secure this effect will require careful consideration of the object to be drawn. Like many other procedures in drafting

there is no exact rule that will apply to all cases, but if the student will use the following method as applied to regular shaped figures, he will be able to use it for irregular shapes by making allowances for the unequal mass appearance of such objects.

Instructions:

1. Secure a piece of scratch paper and a writing pencil.

2. The spacing of a three-view drawing will be explained as anyone will be able to space a two-view drawing if he understands the three-view method.

3. Draw, freehand, an orthographic sketch showing the outline only of each of the three views of the object to be drawn. Place these views in the relative positions they should have as explained under "Positions of Views." The Iron Block that is to be drawn for the first plate may be used as the object, and the sketch will be the same as that shown in Figure 12.

4. Draw a line around this sketch so as to represent the border line that will be placed on the mechanical drawing.

5. Mark the space between the left border line which was just made in step four and the front view "A"; also mark the space between the right border line and the side view "A".

6. Mark the space between the top line of the title space and the front view "B", also mark the space between the top border line and the top view "B".

7. Mark the space between the top and front views "C"; also mark the space between the front and side views "C".

8. Add the overall length (this is the entire outside length) of the front and side views of the object. Subtract this sum from the 12½ inches between the left and right border lines. Divide the difference obtained from this subtraction into three parts in such a way that there are two equal parts, and the third part is not more than ½ inch larger or smaller than one of the other parts. The two equal parts will be "A" and "A"; the third part will be "C". These numbers should be marked on the sketch in the places of "A", "A" and "C".

9. Add the overall height of the front view, the width of the top view, and the dimension for "C" as just determined, and subtract this sum from the distance between the top border line and the line which forms the top of the name plate, this distance being 8 3/8 inches. Divide the difference obtained from this subtraction into two equal parts. Each of these parts will be "B". The bottom "B" may be made not to exceed ¼" larger than the top "B".

10. The numbers found for "A", "B", and "C" are the dimensions to be used in placing the views on the drawing

paper for the first plate. A slight difference in the equality for the dimensions found for each space would not be noticeable on the drawing so that these dimensions need not be worked out closer than about $\frac{1}{4}$ inch.

Figure 13 shows a sketch of the "Iron Block" with the letters in position, and one set of possible figures that will work. Do not be satisfied with using the dimensions given in Figure 13, unless you know how to get them. Otherwise you will have difficulty in spacing all the other plates. Simply use Figure 13 as a check on your own work.

CHAPTER II

DIVISION OF PENCIL DRAWING

Plate I (Iron Block)

I. Purpose:

To show the principle of projection.

To show the method of "blocking in."

II. Tools required:

Drawing board, T-square, 30-60 degree triangle and scale.

III. Supplies required:

Single sheet drawing paper, 6H pencil, and four thumb tacks.

IV. Instructions:

1. Draw the standard border lines including the title space on the drawing paper.

2. The "Iron Block" with all the necessary dimensions is shown in a picture drawing (this is an isometric drawing) marked Plate I. The three views for the orthographic drawing of this object have been explained in "Position of views", and the way they are obtained has been shown in figs. 11 and 12. The dimensions for the spacing of the views as worked out in "Spacing views" will be used.

3. Starting from the top of the title space, measure up the distance to the bottom of the front view as found for "B" on the sketch referred to in step 2. Place a dot, and through this dot draw a line for the bottom of the

front and side views. This should be but one line and should extend nearly across the paper. Use the T-square for horizontal lines.

4. From the line just made, measure up the distance to the next horizontal line and draw that line for both the front and side views. This second line will be the top of the bottom part of the block. Working from the bottom up, proceed to draw all the horizontal lines required for this drawing. There will be seven in all. Make each line of sufficient length that it will be sure to extend past the end of the object which it represents.

5. Starting from the left border line, measure and draw all the vertical lines following the same method as used on the horizontal lines. Work from the left toward the right. Use the dimensions for "A", "C" and "Z" as found on the sketch. The triangle and T-square are used for vertical lines.

6. Do not measure corners or ends of lines, but rather measure about the middle of the line. There should not be a dot at the point where lines meet.

7. Let the lines run over at the corners and do not erase them until after the drawing has been inked in. These lines will help in inking, save time in drawing and do no harm on a simple drawing. With practice the student will be able to estimate the approximate place where a line

should end, and should carry the line just past that point so as not to unnecessarily fill the drawing with extra lines.

8. This method is called "blocking in" the views and should be used to insure that the three views be in their proper position in relation to each other. This makes it possible to project or carry over from one view to the other without measuring for each view.

9. Every edge of an object being drawn must show on the drawing. If an edge can be seen when the object is looked at from the proper position for the view being drawn then that edge should appear as a solid continuous line and is called a visible edge line. The method of showing other edges than visible ones will be explained as needed by the student. The completed drawing should appear as in fig. 14.

10. All the first ten plates shall be done in pencil only for this unit of work and shall not contain dimensions or lettering.

Plate 2 (Clamp Block)

I. Purpose:

To show the use of dotted lines.

To illustrate the technique of dotted lines.

II. Tools required:

Drawing board, T-square, 30-60 degree triangle, scale, thumb tacks.

III. Supplies required:

Single sheet drawing paper, 6H pencil.

IV. Instructions:

1. Properly place the drawing paper on the board and fasten with thumb tacks.

2. Place the standard border lines on the drawing.

3. Make a three view orthographic sketch of the "Clamp Block". Obtain the outside dimensions from the picture drawing of this object marked Plate 2.

4. Figure the spacing for the "Clamp Block" in the same way as was done for plate 1 under "Spacing of Views."

5. Using the blocking in method, draw the outline of the three views as if the block were a solid rectangle without the end cuts or the holes in the center. The blocking in should not be done without thought as to where each line will probably end. A line should be drawn only far enough to be sure that it is past the intersection

with the last line it is to meet.

6. The cuts in the ends of the clamp will appear in the front and end views as visible edges and will be represented in those views as solid lines. The recess and hole in the center top of the block will appear on the top view simply as two squares, and as they are visible they shall be represented with solid lines.

The dotted line: as stated before, every edge of an object being drawn must show on each view of that object (a few exceptions will be discussed later). Those edges that can be seen are drawn as visible edge lines or solid lines. On this drawing we come to edges that cannot be seen, but as they must be shown it is necessary to use another kind of line for that purpose so that we can tell whether an edge is visible or invisible. The line to use for this purpose is the "dotted line". This is a line made up of alternate dashes about one-eighth of an inch long which are separated by spaces about one-sixteenth to one thirty-second of an inch long. The length of the dots and spaces may be increased or decreased somewhat if the drawing being made is very large or very small. Most drawings should be made with the dotted lines constructed as first given. There should never be more than one style

of dotted line used on any drawing. Fig. 15 (a) illustrates a dotted line.

If an edge is invisible for its whole length, then the first and last dots which represent this edge must touch the starting line and the finishing lines respectively. Fig. 15 (b).

If a line is visible for part of its length and then becomes invisible, the first dot where the line becomes invisible should not touch the edge but rather start away from the edge a distance equal to the space in the dotted line. Fig. 15 (c).

If a dotted line meets another dotted line so as to form a corner then both lines should end with a dot so that the corner is definitely located. Fig. 15 (d).

If a dotted line meets another dotted line that continues across the drawing, there should be a dot in each line at the place where these lines meet so as to definitely locate the point of intersection. Fig. 15 (e).

If a dotted line crosses another dotted line, there should be dots in both lines where they meet or cross so as to definitely locate the point of intersection. Fig. 15 (f).

The observance of these rules for dotted lines will greatly facilitate the reading of the drawing especially if the drawing is small or contains a large number of invisible edges.

7. Draw in the invisible edges for the cut shown on each end of the clamp as they appear in the top view. The dotted lines in this case should touch the outside edge lines of the object.

8. Though both of the recessed squares show in the top view as solid lines, it would be impossible to see either of these holes in the front or side views and must therefore be shown in those views as dotted lines. The rules for meeting and crossing dotted lines will need to be carefully followed. The two-inch hole should be drawn in both front and side views first and followed by the smaller hole which goes through the block.

Plate 3 (V Block)

I. Purpose:

To draw slanting lines with the triangles.

II. Tools required:

Drawing board, T-square, 45 and 30-60 degree triangles, scale.

III. Supplies required:

Single sheet drawing paper, 6H pencil, and four thumb tacks.

IV. Instructions:

1. Draw the standard border lines on the paper.

2. Determine the outside dimensions of the "V Block" as shown in the picture drawing, marked Plate III. The three views, top, front, and side are to be made. Draw a free hand sketch of these views in their correct position and figure the spacings.

3. Draw the outlines of the three views as if the block were solid, that is, without showing the V's. Use the blocking in method to insure the views being in line.

4. The "V's" are to be made now in the front view. Locate the point of the largest "V" by means of intersecting horizontal and vertical lines. The dimensions for these lines are shown on the picture drawing. The exact location of a point is more accurately indicated by means of these lines than if a dot were placed at the point. Through

the point just found draw a line at 45 degrees to the right and another at the same angle to the left letting them extend across the top line of the front view and also crossing at their point of intersection through the given point. Figure 16 shows the making of this "V".

5. By the same process of intersecting lines the points of all the other "V's" may be located and the "V's" drawn in with the 45 degree triangle.

6. Every point and line in each view will appear in each of the other views either as a point or as a line. Any point in the top view will be directly above that point in the front view. Any point in the side view will be directly across from that point in the front view. The edges of the large "V" will appear in the top view as solid lines. The edges of all the other "V's" will appear in the top view as dotted lines. The dotted and solid lines for the "V's" in the side view shall be worked out by the student. The rules for dotted lines should be followed. When a dotted line falls behind a solid line the dotted line does not show.

7. The location of the edges of the "V's" in both the top and side views is by means of projection, that is, their location is secured (in the top view) by placing the triangle against the top edge of the T-square and lightly drawing a line from the corner of the "V" in the front view

to the correct position in the top view; (in the side view) by lightly drawing a line along the top edge of the T-square from the corner of the "V" in the front view to the correct position in the side view.

Plate 4 (Adjusting Lever)

I. Purpose:

To give practice in the use of the compass.

To show the construction and use of center lines.

To show a "two view" drawing.

To draw a tangent to a circle.

II. Tools required:

Drawing board, T-square, 30-60 degree triangle, scale and set of instruments.

III. Supplies required:

Single sheet of paper, 6H pencil, and four thumb tacks.

IV. Instructions:

1. Place the paper on the drawing board with the long direction of the paper in a vertical position.

2. Place the standard border line on the paper. On this plate the name plate will extend across the entire bottom end of the paper.

3. For many objects it is necessary to draw only two views. If all the information can be clearly shown on two views then the third view only adds work. Two views would have been sufficient for each of the three preceding plates, but three views were made to learn the position and drawing of these views. Two views, the front and top only are to be made of the Adjusting Lever. It will be

necessary to figure only the spacing between the top and bottom border lines. The object will be centrally located between the side border lines.

4. In beginning a drawing the basic parts of which are circles, it is necessary that the center lines for these circles be the first lines to figure out and to draw. The position for the horizontal center line through the front view should be figured and drawn first, followed by the vertical center line that gives the center of the small circular left end, and then by the vertical center line for the right end.

The center line: the construction of a center line is shown in figure 17 (a). It is made up of dashes about ¾ of an inch long and of dots or rather short dashes about 1/8 of an inch long. Whenever two center lines meet and when a center line meets any other line, they must be made to cross that line. In other words, do not leave a space in a center line at the place where it meets another line. Fig. 17 (b).

5. Read the information on the use of the compass and then draw in all the circles whose centers are at the point of intersection of the three center lines just drawn. Notice that one of the circles in the large right end gives the centers of the series of the small bolt holes and should therefore be drawn as a circular center line.

6. The small bolt holes in the right end may now be drawn using the bow compass for that purpose.

7. In making the slot in the left end, the centers should be found and the half circles drawn in before drawing the horizontal edge lines.

8. The two lines that show the outer edges of the front view, the lines that join the circles at the ends of the lever, are to be drawn tangent to the end circles. A line is tangent to a circle when it is drawn so that it touches the circle but would not enter the circle if it were produced or made longer. It should be noticed that the tangent lines do not meet with the circles at the center lines. The right hand end of this line in the top view will end directly above the point of tangency. Fig. 18 shows how to find the exact point of tangency.

9. The top view may now be drawn. With the exception of the thickness of the two ends, all the lines in the top view are projected from the front view. The two sides of each circle must be represented in the top view. Some of them will appear as visible edges and some as invisible edges. See that the dots for the invisible edges touch both the front and back edge lines.

10. Every circle that appears as a circle on the drawing must have two intersecting center lines to show the center point for that circle. On the edge view of a circle

as found in the top view on this drawing, a center line must be drawn through the center point parallel to the side of the circle. These center lines should extend about three-eighths of an inch outside the edge lines of the object. Fig. 19 illustrates center lines in circles.

Use of Instruments

Compass

The friction joint that is in the head of the large compass should first be tested. There should be sufficient friction to hold the legs of the compass fixed when they are lightly taped with the finger but not so tight that when they are to be adjusted the movement of the legs will be jerky. If the friction is too great it will be difficult to make small adjustments. The spring in the bow compass holds that instrument in adjustment.

Place the pen attachment for the compass in position and adjust the needle point so that the end of the pen will come to the middle of the pen point when both legs are brought together. Tighten the set screw on the side of the needle point so as to hold the needle fixed in this position. Place the pencil leg in the compass and insert a piece of 2H lead in the place provided allowing the lead to extend to the very point of the needle when the two legs are brought together. The outside surface of the lead should now be rubbed on the sandpaper until the lead is chisel shaped (Fig. 20). The inside surface will be straight. Refer to the illustration for the proper shape. The lead should now be set down until the point is about even with the middle of the needle. A sharp lead and correctly adjusted compass will greatly increase the

accuracy and the speed of compass work. The point of the compass should only be pushed into the paper a sufficient distance to prevent the point from slipping. A large center hole prevents accurate compass work. Where the same center is to be used a great many times it would be well for the student to secure one of the center hole protectors that are manufactured for that purpose. To draw a circle hold the handle that is at the top of the compass in the right hand and with the left hand guide the sharp point of the compass so that this point touches the paper at exactly the point desired. The compass should now be tipped slightly in the direction in which it is to be rotated. Let the weight of the compass rest on the lead but do not press down on the lead. The circle can now be made by rolling the handle between the thumb and first finger. The circle should be made in one movement without lifting the compass. The direction of rotation should always be the same, usually clockwise, so that any looseness that there may be in the compass will not make a double circle or other inaccuracies. Remember, do not press down on the compass; if the line is not dark enough the lead needs sharpening or a softer lead should be used. The large compass should be used for all circles over one inch in radius. The bow compass should be used for all smaller circles. The use of the bow compass is similar to that of

the large compass, the only difference being that the spring control and its smaller size make it easier to use, especially for small circles. Fig. 21 shows a circle being drawn with the compass.

Plate 5 (Brake Quadrant)

I. Purpose:

To draw circles that are tangent.

To draw a circle tangent to a line and a circle.

II. Tools required:

Drawing board, T-square, 30-60 degree triangle, scale, set of instruments.

III. Supplies required:

Single sheet of paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the drawing board with the long direction of the paper in a vertical position.

2. Place the standard border line on the paper with the space for the name plate extending across the bottom of the sheet.

3. As in the preceeding plate only the front and top views are required to fully show the Brake Quadrant. Figure the spacing for these two views between the top and bottom border lines.

4. The shape of this object depends upon the location of the centers of the circles. The first lines to be drawn should therefore be the horizontal center line, the right end vertical center line, and the circular centerline

for the left end, in their respective order. Notice that the center of the circular center line for the left end is at the intersection of the center lines for the right end.

5. Locate the centers of the outer left end circles by drawing two short center lines one and one fourth inches above and below the long horizontal center lines. With the three centers found so far draw the circles for the right end and the outer circles for the left end. The small circles for the slot at the left end may also be drawn now.

6. With the intersection of the center lines at the right of the drawing as a center draw tangent arcs to each of the two sets of circles on the left end. Unless the work in drawing the small circles has been done very carefully, it will be found that the arc does not come tangent to both sets of circles. Fig. 22 shows the left end as made so far.

7. The small circles for the center recessed portion and the horizontal lines that are tangent to them may be drawn now. Also draw the top and bottom lines that are tangent to the outer right hand circle. To draw the arc at the left end of these lines it will be necessary to carefully follow the construction shown in figure 23. Draw the tangent arcs, circles and lines so exactly that

there is no brake in the evenness of the curve; that the intersections are the width of only one pencil line.

8. The top view should now be drawn. Most of the points and lines will be obtained by projection from the front view. The location of the arc for the left end of the recess will need careful observation. There are three points where the triangle will be tangent to the sides of the slot when projecting from the front to the top view so there will be three dotted lines to represent the slot in the top view. Complete the top view by drawing the center lines for the circles.

Plate 6 (Rocker Arm)

I. Purpose:

To locate and draw arc from external centers.

To draw fillets.

To show the need of developing all views collectively.

II. Tools required:

Drawing board, T-square, scale, 30-60 degree triangle, set of instruments.

III. Supplies required:

Single sheet of drawing paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the board in a vertical position.

2. Place the standard border line on the sheet with the name plate across the bottom.

3. This will be a two view drawing. The top and front views. Figure the necessary spacing and draw the horizontal center lines for the front and top views; the vertical center line through the middle of the paper, and the center lines for the outer ends.

4. The circles in the center and right end of the front view and the single circle on the left end of the top view should now be drawn in.

5. Project the circle on the left end of the top

view to its position in the front view. The three quarter inch arc which gives the shape of the front end of the rocker arm should be put in next.

6. Carefully study the picture drawing and find the dimensions given for the location of the centers for the two large curves that form the front end of the Rocker Arm. Locate these two centers on the front view and draw in the two arcs that use these centers. The smaller arc should come tangent to the large center circle. The top or larger arc should be made tangent to the small front end arc but should pass over the large center circle.

7. The two straight lines that form the top and bottom of the right end of the Rocker Arm are to be drawn tangent to the two arcs that they meet. The bottom line is tangent to the small end circle and to the large center circle. The top line is tangent to the small end circle and to the large front arc that has just been made. Complete the top view.

8. The word fillet comes from the pattern shop. It means the rounding off of inside corners to assist in molding the pattern. All inside corners of objects to be made of cast iron should be rounded off if possible, and these arcs are usually shown on the drawing. The fillet also increases the strength at the corner. The picture drawing shows the location and size of fillets to be used.

Figure 24 shows one method of locating the center for small fillets so that they will be made tangent to the lines they join. Guessing at these centers usually results in poor looking tangents. Notice that there is one small fillet at the left end of the front view, all the other fillets will show only on the top view. When two fillets on the same surface intersect, their intersection will form a line which bisects the angle at which the fillets intersected. This is illustrated in figure 25 and applies to the fillet at the left end of the top view.

Plate 7 (Cone Pulley)

I. Purpose:

To show the use of cross sections.

To show how to cross hatch.

To give practice in the use of tabulated dimensions.

II. Tools required:

Drawing board, T-square, triangles, scale, set of instruments.

III. Supplies required:

Single sheet of paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the board in a horizontal position and draw the standard border lines.

2. It will be necessary to make but two views of the Cone Pulley, those which come in the position of the front and side views. The circular view of the Cone Pulley looking at it from the large end will be drawn in the position of the front view. The side of the pulley will be drawn in the position of the side view. A center line between the top and bottom border lines will space the views between these lines. Figure the spacing between the right and left border lines allowing a little more than one third of the space between the two views as it will

later be necessary to place several dimensions in this space.

3. As in most circular work the view showing the circles should be drawn first, in this case it will be the front view. The vertical center line for this view should be drawn before making any of the circles. The diameters of the circles may be measured along the horizontal center line and marked with small dots. The compass should be set from the center to each dot in turn and the circle of each drawn. It is not usual that all of any one view can be drawn in complete before working on the other views but in this case it is possible to draw the front view complete before doing any of the work on the side view. It may make it easier for the student however to draw only the visible edges on the front view first, then projecting the sides of these circles to the side view and returning to complete the front view after the side view has been partly laid out.

4. It very often simplifies a drawing to be able to show the inside construction without using a great many dotted lines. To do this we may imagine that some part of the outside of the object has been removed, making it possible to see the inside. The removal of such a part and the drawing of that which can be seen after its removal is called making a section drawing. When the two halves of

an object about a center line are similar, that is, of like shape and construction, sometimes one-half of this view is drawn in section, and the other half of the object in regular view. If there is no detail on the inside of the object being drawn that needs special attention, the section view is not necessary. There are other kinds of sections but the one explained is to be used for the cone pulley. In this case the upper right hand quarter of the cone pulley is imagined removed when looking at the front view drawing. This section is not shown as removed on the front view however, but only on the side view.

5. That part of the object that would be cut if this piece or section were actually cut out of the pulley will be indicated by drawing lines across that surface which is cut. This is called crosshatching. Reference to the sections conventions will show that different materials are crosshatched with different kinds of lines and in different styles. The crosshatching lines for cast iron are drawn at a slant of forty-five degrees to the right. They should be spaced about 1/16" apart, and it would be advisable to measure a few at first to get a good idea of the correct spacing. Be very careful to space these lines evenly. Crosshatching may then be said to show two things: first, that the object is being shown in section, and second, the kind of material of which the object is to be

made. Fig. 26 shows the crosshatching for different kinds of materials.

6. It will be noticed that there are three ribs that connect the hub and the rim of the pulley. If one of these ribs is drawn in a vertical position on the front view, it will fall on the section line and will therefore appear as cut in two on the side view. Sometimes ribs of this kind are not shown on the side view at all, but are omitted from that part of the drawing. On this drawing the rib that shows in section will be drawn, but the other two will not be drawn on the side view. In order that a distinction may be shown between the solid body of the cone and the thin rib only every other one of the crosshatching lines shall be drawn across that part of the section which shows the cut through the rib. Fig. 27 shows crosshatching through a rib.

7. The power from a shaft is transmitted to the pulley by means of a key which is notched or set half into the shaft and half into the pulley hub. The size keyway to be used always depends upon the size of the shaft. The size to use on this job will be found by referring to the table given in fig. 28. The keyway should be drawn on the front view first. If the student will mark the correct width each side of the center line and draw the lines showing the width of the keyway first, this will give the

point of intersection of the keyway with the hub and provide a line on which to measure the depth of the keyway in the hub. Notice that this depth is not measured on the center line of the hub.

9. Do not forget to put in the small fillets that are used to round off all of the inside corners. The corners where the webs meet the hub and outer part should also have fillets which will show on the front view.

STANDARD SIZES OF KEY-SEATS

Size of Bore or Shaft	A Width of Key-seat	B Depth at Side of Key-seat
1	1/4	3/32
1 3/16 to 1 3/8	5/16	7/64
1 7/16 to 1 5/8	3/8	1/8
1 11/16 to 1 7/8	7/16	9/64
1 15/16 to 2 1/8	1/2	11/64
2 3/16 to 2 3/8	9/16	3/16
2 7/16 to 2 5/8	5/8	13/64
2 11/16 to 3 1/8	11/16	15/64
3 3/16 to 3 3/8	3/4	1/4
3 7/16 to 3 5/8	13/16	17/64
3 11/16 to 3 7/8	7/8	19/64
3 15/16 to 4 1/8	15/16	5/64

Note: Key-seat in shaft is same depth as B.

For square keys, B = 1/2 A

Figure 28

Plate 8 (Bracket)

I. Purpose:

To show the use and construction of auxiliary views.

II. Tools required:

Drawing board, T-square, triangles, scale, set of instruments.

III. Supplies required:

Single sheet drawing paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the board in a horizontal position and draw the standard border line.

2. In order that we may show the true shape of an object (which is the purpose of mechanical drawing as compared with picture drawing) it is necessary that the observer, or the line of sight, shall be perpendicular to the surface of the object that is being drawn. There are many objects that the usual three-view drawing of which would not enable the draftsman to show the true shape of every surface. If the shape of the object is of a simple nature or of regular form, it may not be necessary to show that surface; however, when it is necessary to show the true shape of a surface and this cannot be done with the use of only the usual three-view drawing, an additional view of

that part of the object required may be made. This extra view is called an auxiliary view. The auxiliary view is drawn perpendicular to the side view of the surface the shape of which is desired and the rules of projection and the methods of projection are followed as in any other two-view drawing except that the projection is not done in horizontal and vertical directions but rather at whatever angle will make the auxiliary view perpendicular to the side view of that surface. When an auxiliary view is made, the whole of the object is not shown in that view but only that part for which the auxiliary view is being made with just sufficient lines to show the connection of this part of the object to the main body of the object. Figure 29 shows three drawings containing auxiliary views.

3. The drawing for the "Bracket" will require a front view, a top view, and an auxiliary view of the right side. In the top view the right side will not be shown as it would not appear there in its true shape and would therefore add nothing that will help in making the "Bracket" in the shop. The auxiliary views of the "End Wrench" as shown in Figure 30 are very similar to the auxiliary view required for the "Bracket".

4. Due to the auxiliary view, it would be rather difficult to figure the spacing for this drawing, so an estimate of the spacing required may be made. From one to

two inches should be allowed between the front view and the auxiliary view.

5. The 30 degree triangle will give the angle of 150 degrees in the front view. It should also be noticed that the 30 degree triangle will give a line that is perpendicular to the slanting surface in the front view. In other words, the 30-60 degree triangle will give the correct angle for both the right side of the front view and also all of the straight lines in the auxiliary view. There are no other new points of construction in this drawing. Remember that center lines and circles should be drawn first.

Plate 9 (Bolts and Threads)

I. Purpose:

To show the methods of drawing threads on bolts.

To show the method of drawing bolt heads.

To show broken shaft ends.

To show L. and R. hand threads.

To show the method of shortening a long object.

II. Tools required:

Drawing board, T-square, triangles, scale, set of instruments, limb protractor (optional).

III. Supplies required:

Single sheet drawing paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the board in a horizontal position and draw the standard border lines.

2. Divide the paper into two equal parts by a vertical line through the center of the sheet. Divide the left half of the sheet into two equal parts by a vertical line through this half of the paper. Divide the right half of the paper into two equal parts by a horizontal line through the center of this half of the paper. There are to be four objects drawn on this one sheet, this division will make the proper spacing.

3. The methods of showing threads on bolts and taped holes should receive the greatest attention and care of the [illegible] hardly a machine drawing made that does not contain the representation of threads in some form or other. Nearly all machines are made up of more than one piece, and the different pieces are usually connected in some manner by means of threaded parts. There are many forms of threads that are used for various purposes but the thread used most for machine construction is the United States Standard Thread. An exception to this is the use of the S.A.E. or the Society of Automobile Engineers which is used for nearly all automobile engine construction. The shape of the S.A.E. thread is the same as that of the U.S.S., but the number of threads per inch is more. The sharp V thread form is used for all pipe work, and also for some machine parts such as bolts: three thread shapes are illustrated in Figure 30. The methods of representing threads on a drawing is the same regardless of the kind of thread used unless the drawing is of such size that the true shape of the thread should be drawn. There are other exceptions to this general principal such as the square and acme threads which have their own conventional methods. Four of the methods that are most commonly used in representing threads are illustrated in Figures 31 to 34.

4. There are three terms that should be remembered in connection with threads, these are, pitch, lead, and root diameter. The pitch is the distance between the points of two adjacent threads or the distance between two corresponding points on adjacent threads. For illustration, if a string is wrapped evenly around a round stick so that there are 12 turns in one inch of stick length, then the pitch for this thread would be the distance between each of the turns of the string. If we wanted this distance in inches, it would equal the length, which is one inch, divided by the number of threads there are for each inch, this would give 1/12 of an inch for the pitch. From this we can form the rule that the pitch is equal to one divided by the number of threads there are per inch. The number of threads per inch for a given thread shape and given diameter have become standardized, and if the diameter of a bolt is known the number of threads that that bolt should have will be found by refering to the "table of standard threads". Figure 35.

5. The lead of a screw is the distance that a screw will advance into a threaded hole if the screw is turned one complete revolution. If the thread is a single thread, that is, one that is formed by wrapping but one piece of string around a rod, then the lead of the thread is equal to the pitch of the thread as one revolution of the screw

will advance the screw a distance equal to that between the points of two adjacent threads. When the threads on a screw are formed by two equally spaced pieces of string on a rod, the lead will be equal to the distance between adjacent points on the same string; this will be seen to be equal to twice the distance between the points of the thread, and we find that the lead on a double threaded screw is equal to twice the pitch of that screw. A double threaded screw will increase the speed at which the screw will advance but decreases by one-half the pressure that that screw will transmit under a given force. In a triple thread screw the lead is three times the pitch. Figure 36 illustrates lead and pitch.

6. The root diameter of a screw is the diameter of the bolt at the bottom of the threads. This dimension is used frequently as it gives the size drill that should be used to make the hole for a given size tap. "Tap" is the name of the tool that is used to thread a hole. The drill used to make the hole is called a "tap drill". The tap drill size and the root diameter are not exactly alike as different materials requir e different allowances for threading. Figure 30 illustrates root diameter.

TABLE OF STANDARD THREADS

nominal diameter	number of threads per inch: U.S.Std.	S.A.E.	pipe thd	tap drill size to produce approx. 75% depth thread: U.S.Std.	S.A.E.	pipe thd.
1-8	32	[illegible]	27	3-32	7-64	11-32
3-16	24	[illegible]		9-64	5-32	
1-4	20	[illegible]	18	3-16	7-32	7-16
5-16	18	20		1-4	17-64	
3-8	16	[illegible]	18	5-16	21-64	37-64
7-16	14	[illegible]		23-64	25-64	
1-2	13	20	14	27-64	29-64	23-32
9-16	12	18		31-64	33-64	
5-8	11	18		17-32	37-64	
11-16	11	16		19-32	5-8	
3-4	10	16	14	21-32	11-16	59-64
13-16	10			23-32		
7-8	9	14		49-64	13-16	
15-16	9			53-64		
1	8	14	11-½	7-8	29-32	1 5-32
1 1-8	7	12		31-32	1 3-64	
1 1-4	7	12	11½	1 7-64	1 11-64	1 1-2
1 3-8	6	12		1 7-32	1 19-64	
1 1-2	6	12	11½	1 11-32	1 27-64	1 47-64
1 5-8	5 1-2			1 29-64		
1 3-4	5			1 9-16		
1 7-8	5			1 11-16		
2	4 1-2		11½	1 25-64		2 7-32

Figure 35

7. A 3/4" by 3" square headed bolt is to be drawn in the first space provided on the drawing paper, 3/4" being the diameter of the bolt and 3" being the length of the bolt measuring from under the head to the end. This drawing should be made with the threads similar to those shown in Figure 34. The head to be shaped as in Figure 37 (c), the nut to be shaped as in Figure 37 (d). "D" being the diameter, or 3/4" in this case, the other proportions can be found by using the dimensions which are figured from this one dimension. Refer to Figure 38 for the process to be followed in drawing the threads. The light lines on the drawing of a thread represent the point of the thread, while the dark lines represent the root of the thread. The distance between the light lines is equal to the pitch, while the amount of slant is equal to only one-half of the lead as only one side of the bolt can be seen, and therefore, we see only one-half of the lead. Referring to Figure 39, the note on the thread (1"-8 U.S.Std. thds.) should be read as follows: 1" meaning the diameter of the bolt; the dash is simply used to separate the figures; 8 meaning the number of threads there are for each inch of the threaded part; U.S.Std. meaning the threads are to be shaped to conform to the United States Standard thread. Sometimes the 8 is omitted as being unnecessary as this is the number of threads required to conform to a diameter of

1" when made to the United States Standard. The number of threads per inch on a 3/4" bolt is to be found in the "Table of Standard Threads".

8. In the second space on the sheet is to be drawn a hexagonal headed bolt. The diameter and length being the same as for the square headed bolt. This drawing should be made with the threads similar to those shown in Figure 33. The head should be made as shown in Figure 37(a) and the nut as shown in Figure 37(b). The number of threads per inch and the slant will be the same as used for the 3/4" square headed bolt.

9. In the upper right hand space on the drawing sheet shall be a two-view drawing (front and side views) of a shaft that is threaded on one end and broken on the other end. The necessary dimensions are to be found on the pictorial drawing. Methods of showing broken ends are illustrated in Figure 40, that shown at (a) is preferred. The style of threads to be used is that shown in Figure 32. The broken end of the shaft should be crosshatched for cold rolled steel--(Use the symbol for wrought steel.)

10. In the lower right-hand space on the drawing sheet will be made a two-view drawing of the turnbuckle as shown in the picture drawing. The side view in this case should be a section view taken through the middle of the clamp. As stated once before, it is not usual to show

dotted lines in a section view, but when it is necessary to show some part of the object that otherwise might not be plain, then it is permissible to put in the dotted lines. It is therefore best in this drawing to put in the dotted lines on the section view that will show the outline of the end of the turnbuckle as this is the only place on the drawing that the shape of that part will appear. As the rotation of the turnbuckle must draw in both of the bolts, it will be evident that one of these bolts must be threaded with left-hand threads, and the other with right-hand threads. This fact must be shown on the drawing by slanting the lines that represent the threads, one being slanted to the right, and the other to the left of the vertical position, and also by stating that one is a right-hand thread, and that the other is a left-hand thread. The last named method of showing right and left hand threads is not to be put on the drawing until the subject of lettering is considered. It is necessary to make this last drawing only one-half of the size of the given dimensions as the space would not permit of its being drawn full size. This is called drawing to scale half size. The whole dimension will be marked on the drawing, however, when that part of the work is being done. A long object that contains no new information through its middle portion may be shortened in the drawing

by placing a conventional break across the object and then drawing the ends as close together as may be needed. Conventional methods of representing different kinds of breaks are shown in Figure 41. As the turnbuckle is too long even when drawn to scale half size to go on the space provided, it will be necessary to show a break in the middle portion on the front view. The actual length of the turnbuckle in the front view will be about 3 inches. The threads on the rods should be represented by the method shown in Figure 33. The rods should not be shown in the section view. The symbol for wrought steel should be used on the broken ends of the turnbuckle in the section view. The broken ends of the rods in the front view may be made black.

Use of Instruments

Use of limb protractor in draw of threads:

When a limb protractor is used in drawing the threads, it should be held firmly against the T-square and the blade set at the slant of the threads; the protractor can then be moved along the T-square and the threads drawn in their order.

Use of T-square and triangles in drawing threads:

To draw threads by using the T-square and triangle, place the T-square and triangle in their natural position for drawing a vertical line, then while holding these two tightly together, slant the T-square until the vertical edge of the triangle is at the proper slant for the threads. Thumb tacks should now be placed on the bottom edge of the T-square at both ends; this will hold the T-square at the proper slant. The triangle can now be moved along the T-square and the threads drawn in their order. Figure 42 shows the T-square and triangle in their positions.

Drawing small screws or threads:

When the space between the lines which represent the points of the threads on the drawing figure to be less than 1/16 of an inch the correct number of threads should not be shown but rather place the lines for the points of the threads 1/16 of an inch apart. The correct number of

threads required will be indicated by means of a note. This same rule for small threads applies also to tapped holes.

Plate 10 (Eccentric Strap)

I. Purpose:

To show the methods of drawing threads in taped holes.

II. Tools:

Drawing board, T-square, triangles, scale, set of instruments, limb protractor (optional).

III. Supplies required:

Single sheet drawing paper, 6H pencil, pencil eraser, thumb tacks.

IV. Instructions:

1. Place the paper on the board with the long dimension in a vertical position.

2. Draw the standard border line.

3. The "Eccentric Strap" will require but two views. The best views to select for this drawing will be the front and top views. It will be remembered from the work done in plate 4 that when the basic shape of an object is circular the first information required to start the drawing is the location of the center lines for the principle circles. It will be necessary to have the location of a vertical center line through the front and top views, a vertical center line on each side of this center line will give the location of the taped holes that are on each side of the "strap" and horizontal center lines through

both the top and front views will give the location of the center point for the compass for all the circles on both views. The entire front view shall be a section drawing representing the object cut in two on the center line. This section will show on the front view only. Notice that the material is brass and that the cross-hatching for this material is different than that used for iron in Plate 7. Refer to Figure 26 to find the kind of crosshatching lines that should be used.

4. Construct the top and front views with the exception of that part which shows the taped holes. A circle should always first be drawn in that view in which it appears as a circle rather than the view in which its side view appears. If this rule is followed out, the side view of the circle will always be in line with the projection of the circle. In this drawing the student should not attempt to make one view complete before working on the other as this is liable to make the drawing inaccurate and will take much more time than is necessary.

5. The 1/8 inch space which appears at the center line on the "strap" is provided that the two parts may be drawn together. The tightening is done by means of bolts which must be loose in the top half and which is threaded into the bottom half. If a half inch bolt is used as the sketch shows, the hole in the top half will need to be

somewhat larger, (probably 1/16 of an inch larger in diameter,) so that the bolt will not bind on this part. The lower half will need to be drilled and taped to the proper sizes for such a bolt. The size tap drill to use and the size tap that should be used will be found by referring to Table of Standard Threads. Methods of drawing a taped hole are shown in Figure 43. The method shown at (k) will be used for this hole. It should be noticed that as the hole in the top half is larger than either of the circles that show the taped hole in the bottom half, there will be three circles showing on the top view for this part of the drawing. Two will be solid circles and one will be a dotted circle. See Figure 43(d) and (n). The top view of the taped hole which appears in the top center of the "strap" will be drawn as shown in Figure 43(a), (b) and (c). The drawing on the top view for the hole that is marked "1/8 inch pipe tap" will not be a circle but rather an ellipse as this hole comes on the curved side and its true width will not show on this view. In this case it will be necessary to draw the side view of the circle before drawing the top view. It should also be noticed that a 1/8" pipe is not 1/8" in diameter on the outside and that the drawing for this hole will not be 1/8" in diameter. Refer to Table of Standard Threads for the necessary information on pipe threads.

6. In drawing the threads on the front view the student should use a different method of showing threads on each of the places where threads must be represented. Figure 45 shows the methods used for various sizes of taped holes both in section and in elevation. The student should select from these the ones that seem best to fit the size required for each of the threads that he has to draw. The use of different kinds of thread representations for drawings of this kind would not be good commercial practice, but we may be excused in using it in this case so that experience in drawing as many as possible of the different kinds of thread representations may be had by the student. It will also be noticed that when a thread is shown in section they slant in the opposite direction to a thread shown in elevation. In a section view we see the threads on the far side of the taped hole, while in the elevation the threads on the near side are shown.

CHAPTER III

DIVISION OF INKING

INKING

Upon the completion of the pencil drawing for the first ten plates, the student should be able to handle his instruments in a familiar and workmanlike manner so that the thought of their manipulation will not require a great deal of consideration. This will allow him to give attention to the next step in the making of the completed drawing, namely, that of inking in the drawing. While commercial practice would indicate that dimensioning should be the next stage in the process of developing a drawing, it is thought best to have the drawings inked in at this time so that the student will get further work in tool manipulation, and also that he may clean up the drawing and remove all unnecessary pencil lines which might otherwise become confused with the dimension lines. For commercial work a drawing is seldom inked in but rather what is known as a tracing is made from the pencil drawing. Once more we will deviate from the commercial practice until the latter part of the course and will do our first inking directly upon the paper on which the penciling has been done.

Use of the ruling pen.

The condition of the ruling pen will have more effect on the appearance of a finished drawing than any other one instrument, for it is this instrument that is used to ink

in all of the straight lines. The inked drawing is the final piece of work, and though the drawing may be penciled very well, unless the inking is also done carefully there would be little gained by having the good pencil drawing. The points or nibs, as they are called, of a new pen will probably be sharpened correctly, but it would be well for the student to inspect them and see that they are sharp. If they are not sharp, the outer side may be lightly rubbed on a fine grained oil stone; do not grind the inside surfaces. If the pen has been used before, it should be thoroughly cleaned. To do this, remove the set screw and erase all dry ink from both the inside and outside of the nibs with an ink eraser, stroking the eraser toward the point of the pen.

Hold the pen in the right hand with the set screw turned out; grip the pen between the thumb and the point of the second finger with the first finger lightly laying over the outside of the pen to steady it. The thumb should be about opposite the set screw and the second finger halfway between the set screw and the point of the pen. Figure 61 shows the pen held properly. To make a clean edged line it is necessary that both of the nibs touch the paper. It can be seen that it will be necessary to hold the pen nearly perpendicularly to the paper to make both nibs touch. The top of the pen may be slanted slightly toward the right

(not to exceed 15 degrees). The pen is always used with a guiding edge such as the T-square, triangles, or curve, but never as a freehand instrument. Hold the pen against the guiding edge with only sufficient pressure to assure the pen's following the guide. If the pen is pressed against the guiding edge with very great force, the nibs will be squeezed together and a line of varying width will result. The arm of the hand which holds the pen should be kept at right angles or perpendicular to the line that is being drawn; this will place the body of the worker slightly to one side of his pen, thus leaving the arm and hand free to move. The little finger should rest on the T-square and slide along this surface acting as a steadying point. For short lines the little finger may be held still and the hand moved with the finger point as a pivot.

To fill the pen.

When opening a new bottle of ink, first press down on the stopper to loosen the cork from the bottle. It might otherwise break in being removed. With the filler in the left hand and the pen in the right, proceed to fill the pen by placing the point of the quill which is on the stopper in between the nibs of the pen near their point. The ends of the little fingers may be touched together while doing this to assist in steadying the hands. No ink should be allowed to come on the outside surfaces. Do not put more

than 1/4 inch of ink in the pen, and for small work 1/8 to 3/16 inch will be sufficient. When necessary to wipe the pen, the cloth provided for that purpose should be folded, and a corner thus made passed between the nibs so that the inside is wiped. Figure 62 illustrates filling the pen.

To draw a line.

Adjust the set screw on the pen so that the width of the line, or weight as it is called, is the same as that shown for a full weight line in Figure 63. Place a piece of practice paper on the board, hold the pen in the correct manner and the proper position, see that the arm is free to move. At the beginning of each line press the pen slightly into the paper; this will start the ink to flow and also give the line a square end to start with. Hold the pen at a uniform slant for the full length of the line being drawn. Lift the pen at the end of the line with a slight backward movement; this prevents a ragged end to the line. Practice drawing horizontal lines first, and later the vertical lines may be made. Do this until a fair amount of assurance is felt in handling the pen. Horizontal lines should be drawn from the left toward the right. Vertical lines should be drawn from the bottom toward the top of the paper.

Suggestions on inking.

1. If the pen does not write smoothly, do not change

the weight of the line, but wipe out the old ink with the pen wiper and refill with new ink. The pen will need to be wiped frequently while drawing any of the finer lines.

2. The blotter may be used on any line that has a mistake in it and that is to be removed; this will keep the ink from entering the paper and will therefore be more easily removed. Do not use the blotter on any line that is to remain in the drawing as this will make the line pale, thus detracting from the appearance of the drawing; also, if the inking is being done on a tracing the pale line will not make a clear line on the blueprint.

3. Do not use a pencil eraser to remove pencil marks that are close to ink lines as this eraser will remove some of the ink, thus making pale lines with the result noted in number 2. Use art gum for this purpose.

4. Do not leave the nibs of any of the inking instruments pressed together with the set screw as this may bend the points of the instruments and thus make them ink poorly.

5. See that all instruments and the drawing are kept clean and free from any small particles. A very small particle of eraser or dust, if caught in the pen point, will cause a poor line.

6. It will be found very useful if the student will make a line gage by which to test the weight of all lines. This may be made as follows: Secure a piece of tracing

cloth about 1½" square and on this draw three lines, one being the weight or width of a full line, the second being just one-half that weight and carefully drawn as a dotted line; the third line should be a very thin or fine weight line about one-half the weight of the dotted line. Consult Figure 63 for the proper weights of these lines. To use the line gage, first draw a sample line on a piece of practice paper, test its weight with the desired line on the line gage; if the weights are not equal, continue adjusting the pen and testing with the line gage until the practice line is exactly the weight of the corresponding line on the line gage. If this testing is done for each of the different weight lines on every drawing, the student will obtain a uniformity of inking lines that is very beneficial to the appearance of his work.

Inking Plate 1 Iron Block

Instructions.

1. Place the penciled drawing of plate 1 on the board so that the longest horizontal line on the drawing lines up with the T-square. This insures that the ink line will follow the pencil lines.

2. See that the ruling pen is clean and adjusted to the weight of a full line by comparison with the line gage or by referring to the full line shown in Figure 63. Do not fill the pen more than ¼ inch with ink. Try the pen

on a practice piece of paper to see that everything is ready for work.

3. Start at the top of the drawing and ink the first horizontal line below the border line. Start and stop this line exactly at the corners of the block; do not allow them to cross as was done in penciling.

4. Draw the second horizontal line from the top and follow this with each of the horizontal lines in turn as the T-square is moved from the top toward the bottom of the drawing. This order is followed so that the worker will not have to wait for the preceding line to dry. Before starting a line look at the pen and see that it contains sufficient ink to make the line. It is almost impossible to make a joint in the line without that joint showing. Make every line of full weight and of even blackness for its entire length. Draw the lines rather slowly and with great care.

5. Draw the first vertical line from the left border using the tools in the same manner as they were used in penciling. Draw from the bottom toward the top of the paper. Make the joints with the horizontal lines perfect so that there is no crossing or overlapping at the corners. Proceed with the next vertical line to the right. Ink the remaining vertical lines in their order proceeding from left to right.

6. The border lines may now be inked following the order of horizontal lines first and vertical lines second.

To erase an ink blot.

To erase an ink line or blot of ink from a sheet of drawing paper without showing the erasure and leaving the paper in condition that it may be inked on again without blotting requires special procedure. Secure a fine grained ink eraser and with this erase the ink mark until nearly obliterated. With a pencil eraser rub over the same place until all signs of the ink are removed; this will not only remove the ink but will also smooth the paper and leave it in fair condition for inking. To put the paper in a still smoother condition the same spot may be gone over with the art gum. If the ink eraser alone is used it will leave the paper in much the condition of a blotter over which a clean line cannot be drawn.

To use the erasing shield.

Place an opening of the erasing shield that is just a little larger than the spot to be erased over this spot and proceed to erase as explained in the preceding paragraph. The shield protects the other lines so that so much patch or repair work need not be done. The pressure on the shield also helps hold the paper so that it will not be drawn loose from the thumb tacks or stretched at this spot.

Inking Plate 2 Clamp Block

Instructions.

1. Place the paper on the board as in plate 1 with the longest pencil line in line with the T-square.

2. Clean the ruling pen and fill with the proper amount of ink. Adjust the pen to the proper width of line for a full weight line. Draw a practice line and see that the weight is correct.

3. Following the order of inking as explained in Plate 1, draw the top horizontal line following with each of the horizontal lines in turn as the T-square is brought down across the paper. Be sure to stop the ink line exactly at the corners.

4. Ink the vertical lines drawing the one nearest the left first and following in order across the paper from left to right. Make the joints at the corners perfect.

5. So far, only the visible edges should have been inked. The pen should now be adjusted to the weight of a dotted line as compared with the line gage or with Figure 63. Try the pen on a piece of practice paper.

6. The dotted lines should now be inked in following the same order that was used with the full line, that is, ink the horizontal lines first starting at the top and working down, and the vertical lines next, starting at the left and working toward the right. Be sure to make the dotted lines touch and cross at the places where they are

supposed to. The dotted lines will have to be drawn very slowly at first in order that the worker will make the dots and spaces of correct length and all of uniform length.

7. Reset the pen for full weight lines and ink in the border lines.

Inking Plate 3 V Block

Instructions.

1. Place the paper on the board as in Plate 2 with the longest pencil line in line with the T-square.

2. Clean the ruling pen and fill it with the proper amount of ink. Adjust the pen to the width of a full weight line. Draw a practice line and see that the weight is correct.

3. Ink in the horizontal and vertical lines following the order for these lines as worked out in the last two plates.

4. The full weight slanting lines should be inked in next. Use the T-square and triangle together holding them in the same position that was used while penciling. Ink in those lines that slant upward to the right first, starting at the left of the paper and working toward the right. Start inking these lines at their lower left end and draw the pen upward.

5. The lines that slant upward to the left shall now

be inked in. The worker will need to step to the very left end of the drawing board for these lines. His hand that holds the pen must be placed so that it is over the triangle while that instrument is held tightly against the T-square and in position to guide the pen along the line that is to be inked. Start at the top end of this line and draw down toward the lower right end of the line. Draw the line at the right of the paper first and work toward the left. It should be noticed that this procedure from right to left is opposite to that followed for most other inking.

6. Make a perfect joint where the slanting line joins with the horizontal and vertical lines. Do not make them cross.

7. Do not draw an ink line that is to connect with another ink line if the first line drawn is not dry as two wet lines coming together are very apt to cause a blot at the point of intersection.

8. Change the adjustment of the ruling pen to the proper weight for dotted lines. Test this weight with the line gage or with Figure 63. When the weight is correct, the dotted lines may be inked in, following the order of inking as explained in Plate 1.

9. Reset the pen for full weight lines and ink in the border lines.

Inking Plate 4 (Adjusting lever)

Instructions.

1. Place the paper on the board in the same position that it was for penciling. Test the vertical center line and see that it lines up with the triangle when the triangle and T-square are held in the correct position for drawing this line.

2. When a drawing contains visible edges that are circles or arcs of circles, these circles should be the first part of the drawing to be inked in. The reason for this can be seen if the student will draw two parallel lines about one inch apart and try to connect the ends of these lines with a half circle. Now try again, this time drawing the half circle first, and connect the two straight lines to the circle. This exercise will show that it is easier and quicker to make good connections where the circle is drawn first.

Prepare the compass with the ruling pen attachment as explained under "use of instruments". Practice with the compass pen on a spare piece of paper until it can be used successfully. Test the weight of the line with the line gage and make it equal to the weight of a visible edge line. The large complete circles on this plate may now be inked in.

3. Prepare the bow pen for inking and adjust it to the weight of a visible edge line. Ink in all of the small

circles and arcs that should be made with this pen. Be very careful when inking arcs of circles not to carry the ink line past the point of intersection with the intersecting line.

4. The remaining full weight lines may now be inked in in the following order: horizontal lines, vertical lines, slanting lines.

5. If there were dotted circular lines on this drawing, they should be the next to be inked in, but as there are none the horizontal and vertical dotted lines may now be inked in.

6. Wherever circles or arcs of circles are on a drawing, there should be intersecting center lines for each circle or arc which locate the centers for the circles and arcs. Where full circles appear, the center lines must extend just past the outside of the circle; or if the whole drawing is symmetrical about this center line, they should extend past the outside of the drawing. When drawing center lines, be sure that they are made to cross at the point of the center of the circle so that the center of the circle is definitely located. Any light line such as the center line or a projection line that is not a part of the object but is used to make it easier for the interpretation of the drawing should be made to cross every other line that it may meet in its course. This greatly facilitates

the reading of the drawing. Sometimes the center line is an arc of a circle, and when this is the case, the arc center line should be inked in before inking the straight line center lines. A center line should also be drawn through the side view of a circle or hole. In a side view, this is the only way to distinguish between a circle and a rectangle, the circle has the center line. Intersecting center lines which locate the centers for the compass for the large arcs should be drawn in. The weight of a center line should be like that shown in Figure 63 or like the lightest line on the line gage.

7. Ink in the border lines with full weight lines.

Use of instruments.
Inking compass.

Remove the pencil attachment from the large compass and insert the pen attachment. Bring the pen point and the needle points together and adjust the needle point so that the point comes halfway between the point of the needle and the shoulder of the needle. Remove all dry ink from the pen point and have it in a clean, bright condition the same as required for the ruling pen. When using the ruling pen, it was found that the nibs should be kept perpendicular to the paper or a clean edged line could not be made; this same fact is true for the inking compass. The nibs of the compass pen must be kept perpendicular to the

paper. On large circles, those over about two inches in radius, it will therefore be necessary to bend the joint in the leg of the compass that holds the pen a sufficient amount to make the nibs perpendicular to the paper. As the size of the circle being drawn increases, the amount to bend the joint will also increase. When drawing very large circles, those over about four inches in radius, both legs of the compass should be bent so that they are perpendicular to the paper. Rotate the compass in only one direction. Figure 64 illustrates the adjustment of the compass for use on large circles.

Order of inking.

To secure the most satisfactory results, the best appearing drawing, with the least errors in technique, all lines should be "inked in" in the order in which they appear in the following outline:

a. Visible edge circles and arcs of circles.

b. Visible edge irregular curves.

c. Horizontal visible edges, starting at the top of the drawing and inking these lines in the order that they come.

d. Vertical visible edges, starting at the left and working toward the right of the drawing. c and d are done in this order so that the worker need not wait for the ink of the preceding line to dry.

e. All other visible edge lines.

f. Invisible edge circles and arcs of circles.

g. Invisible edge irregular curves.

h. Invisible edge horizontal lines, proceeding as in c.

i. Invisible edge vertical lines, proceeding as in d.

j. All other invisible edge lines.

k. Center line circles and arcs of circles.

l. Center line horizontal and vertical lines in that order.

m. Construction lines. Circles, arcs, horizontal and vertical lines.

n. Dimension lines.

o. Border lines.

p. Dimension arrow heads.

q. Dimensions.

r. Lettering for notes, title and name plate in the order named.

Inking Plate 5 (Brake Quadrant)

Instructions.

1. Place the pencil drawing of plate 5 on the drawing board in the same position as when penciling. Adjust the paper so that the long horizontal center line on the front view will line up with the edge of the T-square.

2. Clean the compass pen of all old ink and adjust it for a full weight line. Test the weight with the line gage. Ink in all the circles and arcs that indicate visible edges and that were drawn in pencil with this compass.

3. Clean the bow pen of all old ink and adjust it to the weight of a full line. Test the weight with the line gage. Ink in all circles and arcs that indicate visible edges and that were penciled with the bow pencil.

4. Ink in the full weight straight lines in the same order as followed on the preceding plates. Horizontal lines, vertical lines, and slanting lines.

5. Set the bow pen to the weight of a dotted line and test this weight with the line gage. Ink in the small arcs of circles that show the ends of the recess on the top view.

6. Set the ruling pen to the weight of a dotted line and ink in the dotted lines on the top view. There are no invisible edges on the front view.

7. The large compass should now be set to the weight of a center line and the circular center line in the left end of the front view be drawn.

8. With the ruling pen properly adjusted the remaining center lines may now be inked in.

9. Ink in the border lines with full weight lines.

Inking Plate 6 (Rocker Arm)

Instructions.

1. Place the pencil drawing of plate 6 on the drawing board in the same position as when penciling. Line the

center line in the front view up with the T-square.

2. There is no new information on inking required for this plate. The same order of inking should be followed as in the preceding plate. See that the correct weight of line for each kind of lines is used. Make the full weight lines of both the compass and the ruling pen of equal weight. All the lines of each kind should be of equal weight. Try to avoid the omission of a line when that kind of line is being inked because the more often the pen has to be adjusted to different weights the more possibilities there are of making varying weights of lines.

Inking Plate 7 (Cone Pulley)

Instructions.

1. Place the pencil drawing of Plate 7 on the drawing board in the same position as when penciling. See that it lines up with the T-square.

2. There are two new kinds of lines found on this drawing, crosshatching and section lines. The crosshatching lines should be inked the same weight as used for center lines, this being the lightest of the three weights used. Be very careful when inking these lines to see that they are spaced exactly uniformly.

3. A section line is found in two places, once on the front view to show there what part has been imagined as

being removed, and also in the side view where the edge of the section comes. In both of these cases, the section line is a center line. Remember in sectioning that it is only imagined that the section is removed and therefore the edge of the cut is not a solid or visible edge line.

4. The drawing may now be inked in in the same order as in the preceding two plates. The crosshatching will be the last part of the drawing to be inked.

Inking Plate 8 (Bracket)

Instructions.

1. Place the pencil drawing of Plate 8 on the drawing board in the same position as when penciling. See that it lines up with the T-square.

2. This plate is a simple one to ink, and the student should therefore try to make the technique perfect. Use the line gage for correct weights of lines. Follow the order of inking as explained before.

Inking Plate 9 (Bolts and Threads)

Instructions.

1. There being four complete and separate drawings on this plate, it may be more convenient for the student to ink each part in as though it were a whole plate. The drawing nearest to the left should be inked in first, observing the correct order of inking as followed on the preceding plates. The line which indicates the root of the

thread should be the same weight as a full or visible edge line. The line indicating the point of the thread is the same as that used for center lines and construction lines, the lightest weight of line used.

2. The remaining three drawings on this plate may be inked in each being made complete in its turn. The irregular lines that show where the shaft, turnbuckle, and rods in the turnbuckle are broken will be inked in freehand with the ball-point pen. Try to make this line the same weight as all other visible edge lines.

Inking Plate 10 (Eccentric Strap)

Instructions.

1. There are several places on the drawing of the eccentric strap where circles must be drawn tangent to other circles and where circles must be drawn tangent to straight lines. This kind of work requires considerable care and great accuracy if the drawing is to appear well and the points of tangency are not to show. There are no new kinds of lines to use on this drawing so the student may proceed to ink it in without further instructions. The lines which indicate the points of the threads in the section view should be inked as visible edge lines. Follow the correct order of inking. Continually strive for greater accuracy, neatness, and better technique.

CHAPTER IV

DIVISION OF DIMENSIONING

DIMENSIONING OBJECTIVES

There are two general objectives or kinds of information that the mechanical drawing must convey to the workman that is making the object. The first of these is that the drawing must so express or convey the idea of the appearance of that object that the workman can form a mental picture of it. The second objective of the drawing is to give the workman all of the dimensions that he may be required to know to insure the object's being made the exact size the draftsman or designer intended it should be. The method of showing the picture of the object as a mechanical drawing has been worked out in the preceding drawings, but it is now necessary to make these drawings usable by the workman in the shop by placing upon them the dimensions that show the size they are to be made. It should be especially noted here that the dimensions that go on the drawing are not those used by the draftsman in making the drawing, but the dimensions that are required by the workman to make the object. The drawing in itself is of no value, but rather its value comes in how successfully the drawing conveys to someone else the required ideas that will enable the second person to make that object. In order that the drawing be dimensioned to the best advantage the draftsman must know or learn the methods of production

used in the shop where the drawing is to be used. He must know the machines that are in that shop and the limitations of each; that is, what it is possible to do with these machines, and what are the best methods of doing a certain job. This means that the machine draftsman must have a knowledge of processes in the pattern shop, the foundry, the forge, the machine shops and other related metal working shops. If the draftsman can obtain his knowledge of these processes by a period of training in each shop, he will have a good foundation for drafting; if such a method is not possible, he should study texts on these subjects and make as many observation trips to the shops as may be possible.

Upon looking over drawings that have been made within the last twenty-five years, it is evident that the methods of dimensioning have undergone changes that assist greatly in reading the drawings, and that standards for dimensioning are developing which it will be well to follow. The general rules that express these standards are given for each plate. As only new rules will be stated in connection with each plate, the student must apply the rules found on any or all preceding plates to the one on which he is working. The rules being of a more or less general nature will require judgment from the student for their exact application to each drawing.

General Directions

1. In order that the mental picture of the object which the workman must get from the drawing is not hindered by extra lines being placed upon the drawing, it is best whenever possible to place dimensions in the space outside of the actual shape of the object. Illustrated in Figure 44.

2. The dimensions should be placed between the different views wherever it is possible to do so rather than on the outer edges of the drawing. Illustrated in Figure 44.

3. Only such dimensions should be placed on the drawing as will be required by the workmen that are going to make the object from the drawing. Dimensions such as the distance an object is from the border line may be helpful to the draftsman but do not affect the making of the object, and should therefore not be placed on the drawing.

4. Do not dimension the same thing more than once though it may appear in more than one view. The width of the Block in Plate 1 appears in both the end and the top views, but the dimension for this width should be given in only one place on the drawing, this may be either above the end view or to the right of the top view.

5. The distance between the dimension line and the object depends somewhat on the size and coarseness of the drawing being made, but for ordinary work a good space to

use is three-eighths of an inch.

6. When a series of dimensions are placed one outside of the other, the same spacing as used for the first one should be used between the other dimension lines. Illustrated in Figure 44.

7. A series of short dimensions (sometimes called detail dimensions) should be placed in line with each other. Illustrated in Figure 44.

8. When a series of short dimensions and the total or overall dimension come on the same side of an object, the short dimension should be placed next to the object, and the total dimension on the outside. Illustrated in Figure 44.

9. A space must be left in the dimension line for the dimension with the exception as noted in the following rule. One-half inch is about the right amount of space to leave, though this will depend upon the space available.

10. If the dimension that is to be placed on the dimension line is a whole fraction and not a mixed number the drawing will appear neater and time can be saved if no space is left in the dimension line but the numerator and denominator of the fraction written above and below the dimension line respectively. Illustrated in Figure 44.

Writing the dimension and arrow heads.

11. Make all dimensions of equal height; a large space does not call for a large figure.

12. The size figure to use depends somewhat upon the drawing being made, but for drawings such as are being made in this course, a good height to use is one-eighth of an inch for whole numbers and one-fourth of an inch for fractions. It should be noted here that $\frac{1}{4}$ of an inch is the total height of the fraction and that each part thereof will need to be slightly less than 1/8 of an inch so that the figure will not touch the division line which comes between them. The figures should be shaped like those shown in Figure 45. Shape them carefully; this is printing and not writing.

13. Guide lines should be drawn for the tops and bottoms of all dimensions to insure their being of equal height. A rapid way to measure the height is to set the bow dividers at one-eighth of an inch, make two little punch marks in the paper equal distance each side of the dimension line and then draw guide lines through these punches parallel to the dimension line. The spacing for fractions may be made by setting the bow dividers at 1/8 of an inch as used for the whole numbers, place one leg of the dividers on the dimension line and make a punch in the paper each side of the dimension line, the space each side

of the fraction line may be estimated. Illustrated in Figure 46.

14. All dimension must read from the bottom or right hand side of the drawing. This means that dimension may be written so that they may be read by a person standing either at the bottom of the drawing or at the right hand side of the drawing. If the dimension line is horizontal, then the dimension must be written so that it can be read from the bottom of the drawing. If the dimension line is vertical, then the dimension must be written so as to read from the right side of the drawing. Illustrated in Figure 44.

15. So that the slant of the dimensions and other lettering may be similar, all dimensions shall be written at a slant of 60 degrees to the dimension line in which it is placed. A fuller statement on the slant of letters will be found under the discussion on lettering.

16. The line at the end of the dimension line is called an extension line. This line should not touch the object being dimensions, but should start a short distance away from the object, from 1/16 to 1/32 being about the right amount. The extension line should also extend about one-eighth of an inch past the dimension line. Illustrated in Figure 47.

17. An arrow head must be placed at both ends of each

dimension line to show the exact end of that dimension. The point of the arrow head must just touch the extension line. A good shape to make the arrow heads is about 3/16 inch long by 1/16 inch wide. The proper shape and location of each arrow head is very important and greatly affects the appearance and ease of reading the drawing; do not overlook its value and neglect this part of the job. If at all possible, the same size arrow head should be used for all parts of the drawing; do not make a large arrow head just because there happens to be plenty of space to do so. Illustrated in Figure 48.

Figure 49 and Figure 71 illustrate simple drawings that are properly dimensioned and should be carefully observed by the student while he is dimensioning the first few drawings.

Dimensioning Plate 1 (Iron Block)

1. Place the drawing of Plate 1 on the board in the same position as used in penciling and in inking. Do this by lining up one of the long horizontal lines of the drawing with the T-square.

2. All the dimensions for this plate will come either between the front and side views or above the front and side views. There should be no dimensions around the outside edges of the drawing.

3. Every one of the rules that are given under the first 17 general directions for dimensioning have application to this first plate.

4. All work of dimensioning shall be done in pencil first. The inking in is to be done after all the ten plates are dimensioned. Dimensioning includes the dimension line, extension line, arrow heads, and the dimension itself.

5. The dimension and extension lines should be drawn with the 6H pensil. The arrow heads and the dimensions should be made with the 1H pencil. The 1H pencil is much softer than the 6H pencil making it easier to control the movement in shaping the letters and figures.

General directions applying to Plate 2.

18. When a rectangular hole is to be dimensioned, the dimensions should be written in the hole on the view where the shape of the hole appears. Both the length and width of a hole should be given even though it is square.

19. A dimension should not be given to a dotted line or invisible edge unless that is the only place where that part of the object can be dimensioned.

20. Usually the dimension should be written in such a place that the extension line at the end of the dimension line does not have to cross a visible edge line.

Dimensioning Plate 2 (Clamp Block)

1. Place the drawing on the board in the same position as used for pencilling and inking.

2. The dimensions for the cuts in the bottom corners will need to be spaced below the front view. Notice that the 3/8 inch spacing for the dimension line should come below the bottom of the object and not 3/8 inch below the top of the corner cut. The outer extension line for this dimension will be drawn from the top of the cut and not from where the corner of the block would be if the cut were not made. The extension lines will be of unequal length. This point is illustrated in Figure 50.

3. It will be necessary to place the depth of the 2 inch square hole on either the front or end views from the top line to the dotted line that shows the depth of the hole. (Rule 20.)

4. The dimension for the 1 inch square hole should be placed as in rule 18. The dimension from the one-inch hole to the two-inch hole should be placed in line with the dimension for the one-inch hole.

5. There are three possible ways to dimension the two-inch hole. The preferable way would be to use the same method as used for the one-inch hole, but this makes a confusion of dimensions in that space. The second way would be to draw the extension lines to the outside of the object

and place the dimensions off the object, but rule 20 shows that this is not a good method. The third method would be to draw the extension lines outside of the two-inch square but keep them on the main body of the object, spacing the dimension line 3/8 inch from the two-inch hole. Rule 1 states the objection to this method. As it is evident that there are objections to each of the three methods, the student must decide which way he will use that will interfere the least with the picture of the object.

Note: This long discussion of such a simple dimension is entered so that the student will see and realize that the placement of a dimension requires consideration and should not be placed without thought.

General directions applying to Plate 3.

21. When an angle is to be dimensioned, the dimension line will be an arc whose center is the point where the lines which form the angle meet. Figure 51 shows three methods of placing the dimension.

22. When the angle of a slanting line is given, it is necessary only to give dimensions for the location of one end of this line. If the angle between two lines is given, and the angle of one of these lines to either the horizontal or vertical base is known, then only the vertex of the angle need be dimensioned.

Dimensioning Plate 3 (V-Block)

1. Place the paper on the board in the same position as used for pencilling and inking.

2. Place the overall dimensions of the block as on Plate 2.

3. Dimension the angle at the vertex of each of the "V's". (Rule 21.) (Figure 51.)

4. Give the dimensions locating the vertex of the "V's". Figure 52 illustrates the method of doing this. (Rule 22.)

General directions applying to Plate 4.

23. When a complete circle appears on a drawing, the diameter for that circle should be given, the dimension usually being placed on that view which shows the circle. The methods of dimensioning a circle are illustrated in Figure 53.

24. If the arc of a circle only appears on the drawing, the radius for that arc must be given, and the center from which the radius is drawn shall either be located by dimensions or be apparent beyond possible error. It requires two intersecting dimensions or lines to locate a point. Methods of dimensioning arcs of circles are given in Figure 54.

25. Where the shape of an object is based on several circles or where parts of an object are circular, the di-

mension for the location of the centers of each of the parts should be given in relation to main center line of the object.

26. Total lengths for objects whose extremities are circular are usually not required. The distance between the centers of the extreme circles being given.

27. Small circular holes may be dimensioned by running an arrow to the circumference from some convenient point outside of the object and placing the size of this hole together with the word "drill" or "ream" as the case may be, at the end of the arrow which is off the object. Such dimensions should always be written horizontal or vertical and not at a slant.

28. If a radius line is drawn as slanting to the left of the perpendicular, the dimension in that line should read from the bottom of the paper. Illustrated in Figure 55. This rule also applies to any slanting dimension line.

29. The dimension for a circle either as a radius or as a diameter should never be written on the center lines for that circle; rather place them at an angle to the center lines. Figure 56.

Dimensioning Plate 4 (Adjusting Lever)

1. Place the drawing on the board in the same position as when penciling and inking.

2. As this is the first plate containing circles, it will be necessary to follow carefully the rules that relate to dimensioning circles.

3. The circular right end should be dimensioned by giving the diameter. This may be placed either to the right of the object or between the front and top views. The central hole in the right end should be dimensioned directly on the hole with the word "drill" inserted in the dimension line. The radius for the left end may be indicated by giving the whole width of the slot or by giving the radius of the half circle; the first method is best in this case, as this is a cored hole and would be made in the pattern by the pattern maker with an auger, and as augers are dimensioned by their diameter, the diameter would be the best to give. The size of the four small drilled holes should be given as explained in rule 27.

4. The thickness of the object should be shown by a dimension at each end of the top view.

General directions applying to Plate 5.

30. When the radius of a circle is to be dimensioned, the arrow for this dimension should extend from the center of the circle to the circumference. If there is sufficient room on the radius line to give the dimension, it should be put on the line in the usual method of placing dimensions. If the space is small, the dimension should not be written

smaller but rather some method of placing the dimension where more space is available should be used. Whenever the dimension is removed from its natural radius position, the dimension should be written either on the horizontal or vertical, not slanting. Some methods for marking radii are given in Figure 54. Notice that an arrow head is placed only at the end of the arrow that touches the circle; do not place an arrow head at the center of the circle. If the center of the arc is removed from the main part of the drawing, or if it is at such a place as not to clearly show its location, then a small circle of about 1/16 of an inch in diameter may be placed around the center point.

Dimensioning Plate 5 (Brake Quadrant)

1. Place the drawing on the board in the same position as when penciling and inking.

2. The method and location of dimensions for this plate are very similar to those on Plate 4, and most of the dimensions may be put on without further instructions.

3. On the top view the dimensions for the thickness of the middle section and for the depth of the recess will need to be placed on the object. Other dimensions may be placed about as shown on the picture drawing.

General directions applying to Plate 6

31. When a number of dimensions are placed one outside

of the other as in rule 6, the figures should be placed on alternate sides of the center line. This is done so that the figures will not interfere with each other and to make each number stand out more clearly. This rule is illustrated in Figure 57.

32. Wherever possible the dimension should be written in the dimension line between its terminating extension lines, but in the case of small dimensions this is not always possible. Three other possible ways of placing small dimensions are shown in Figure 58. The illustrations are lettered in their order of preference - A first, B second, C last.

Dimensioning Plate 6 (Rocker Arm)

1. Place the paper on the board in the same position as used for penciling and for inking.

2. All the dimensions for the thickness of the parts of the object should be placed on the top view at one end of the drawing and arranged as a series of equally spaced dimensions. (Rules 6 and 8.)

3. The large dimensions such as the distance between centers and the dimensions for the location of the large arcs should now be put in the front view. (Rule 24.)

4. The dimensioning of the small circles at the right end of the front view will require planning to make them

plain. The center hole in this end is marked for drilling. Put in the fillet radii as shown in Figure 54.

General directions applying to Plate 7.

33. If a dimension is to be written on a crosshatched surface a small opening in the crosshatching lines should be left around the figures. This may be made neatly by drawing a pencil circle just large enough to enclose the figures and when inking the crosshatching lines stop them when they come to the circle. The pencil circle should not, however, be inked in. Figure 59.

Dimensioning Plate 7 (Cone Pulley)

1. Place the paper on the board in the same position as used for pencilling and for inking.

2. The position of the dimensions on this plate will be somewhat different from that on any of the preceding plates. Rule 2 shows that the dimensions should be between the views, but as it was necessary to turn the large end of the pulley toward the center to better show the webs, some of the dimensions will need to be placed on the right of the end view. Give here the outside diameters of the three steps.

3. The diameters of the shaft hole, hub, and the inside step diameters will be placed between the views.

4. The dimension for the width of each step should be

given as in rules 7 and 8.

5. The thickness of the web will be written on the front view. The length of the hub will be given on the end view. The thickness of the metal should be marked for each step directly on that surface in the section view. The crosshatching lines around the dimension should be omitted, thus leaving the dimension clear. Dimensions on crosshatching are illustrated in Figure 59.

The size of the key way may be given as a note in the nearest space available, thus: "3/8" x 1/8" keyway."

Dimensioning Plate 8 (Bracket)

1. Place the drawing on the board in the same position as used for penciling and for inking.

2. Most of the dimensions for the Bracket should be placed between the views. The circles on the top and auxiliary views should be dimensioned from center to center. The angle for the right end in the front view should not be omitted.

3. Study Rule 28 and make the dimensions on the slanting lines read from the right direction.

General directions applying to Plate 9.

34. Sometimes the dimensions for an object are given in terms of the basic or principal dimension for that object. This makes it possible to figure the dimensions for

all parts when only the one basic dimension is known. Bolts are usually dimensioned in this way, the diameter being the basic dimension.

Dimensioning Plate 9 (Bolts and Threads)

1. Place the paper on the board in the same position as used for penciling and inking.

2. The only figures for the bolt that will be placed on the drawing will be the diameter and length of the bolt, the length of threaded part, and the note which gives the necessary information about the threads. All other dimensions should be expressed in terms of the diameter. Figure 60 illustrates the required dimensions. Refer to paragraph 7 on how to read the dimensions for threads as given in the directions for drawing plate 9.

3. All necessary dimensions required to make the threaded shaft end should be given including the note on threads. The diameter of the threaded part, the diameter of the middle shaft, and the length of the threaded part are required dimensions.

4. Though it was necessary to make the drawing of the turnbuckle only one-half the size of the dimensions given in order that it would go in the space usable for the drawing, the dimension of the full size should be placed on the drawing. In the middle section where the brake was

made to shorten that part, the full dimension should be placed the same as if the drawing were not broken. The notes for the threads should show that they are left and right hand threads. The note for the right end should read: 3/4" U.S. Std. L. H. The L. H. means left hand. The note for the left end should be followed by R. H.

General directions applying to Plate 10.

35. When a small threaded hole is to be made in an object, the hole is first drilled to a size which is about equal to the root diameter of the threads and then tapped. The drill used for this purpose is called a tap drill though it is no different than any other drill. Most machinists know the size tap drill for any standard thread, but due to the different kinds of material, the methods of tapping and the fit required, it is best to give the tap drill size in the same note which states the number and kind of threads. Only one arrow should be brought to the hole for this combined note.

Dimensioning Plate 10

1. Place the drawing on the board in the same position as used for penciling and inking.

2. As this is the last plate of this group to be dimensioned, no specific directions for the placing of dimensions will be given. The student is expected to apply

all rules and directions received for the preceding plates.

3. Some dimensions that might be overlooked are called to attention: the drill size for every threaded hole, the tap size for every threaded hole, the height of the boss on the top of the strap, dimensions for the location of the pipe threaded hole, dimensions for the recessed part on the inside of the strap, and the distance from the center of the main circle to the centers of the holes on the sides.

"Inking in" the Dimensions

1. After completing the penciling of dimensions for all of the ten plates they should then be "inked in", starting with Plate I and continuing through in consecutive order.

2. In inking the dimension and extension lines, the ruling pen should be set at the lightest weight line given on the line gage, which is the same as that shown in Figure 63. If a heavy line is used for this purpose they will become confused with the visible edge lines of the object, making it hard to obtain a picture of the object.

3. The arrow heads and dimensions are very important and should stand out clearly on the drawing; this is not done by making them large but rather by using a fairly heavy weight line. The ball pointed pen #516F made by D. LEONARDT & Co. makes a good arrowhead and the #621 or #702

pen made by the Esterbrook Steel Pen Manufacturing Co. makes a good weight for the dimension. If only one pen is used for both purposes the #621 or #702 should be used.

4. The dimension and extension lines should be inked in in the same order as for visible edge lines, that is, circles and arc, horizontal straight lines starting at the top, vertical straight lines starting at the left, and last slanting straight lines.

5. Start at the upper left hand corner of the paper and work down toward the lower right hand corner when inking the dimensions and arrow heads. This will make it possible to work continuously without waiting for the ink on each dimension to dry.

CHAPTER V

DIVISION OF LETTERING

LETTERING

The set of drawings that are being made are still incomplete, they are not ready to be called working drawings. It is necessary that certain information be given to those who make the object from the drawing other than just dimensions. The only way to convey or show the remaining directions is to give written instructions concerning them. Sometimes these instructions are very extensive and require their being written on a separate sheet which may be attached to the drawing, and in such cases are called specifications. Usually in machine drawing the information can be placed on the drawing itself in the form of notes on material and finish, procedure in construction, and a descriptive title or name plate. As this written material or lettering is an essential part of the drawing, it can readily be seen that it must be legible beyond a doubt. Also the appearance of the drawing may be completely spoiled by careless lettering. This old expression is worthlearning, "Good lettering is essential to good mechanical drawing; many an otherwise excellent drawing has been spoiled by poor lettering." Lettering is an independent subject from mechanical drawing; the letters being formed freehand and not with the use of the drawing instruments.

The Study of letter Shapes.

The form of letter most commonly used in mechanical drawing is the Single Stroke Commercial Gothic Letter. The Single Stroke means that the width of the lines of the letters will be that made by a single stroke of the pen or pencil; the "Commercial Gothic" is a simplified or slightly changed form of Gothic letter making it best adapted to commercial use.

There are two kinds of single stroke Gothic letters, the upper case or caps and the lower case. All the lettering on the first ten plates will be in caps. An alphabet in caps is shown in Figure 65. If you will notice carefully, it will be seen that the letters are not of equal width and that the spaces between the letters are not equal. While the satisfactory shaping and spacing of letters depends largely upon a good "eye" there are several general rules or directions that the beginner can observe.

1. The slant of all letters must be uniform.

2. The tops and bottoms of the letters must be kept exactly in line. (When the draftsman has become sufficiently practiced to be able to do neat lettering, he should study a more extensive treatise on lettering, and he will find therein that slight changes are made in certain letters other than stated herein.)

3. A uniform weight of line must be used on all letters

of equal size and importance on the same drawing.

4. Shape all letters exactly as given in the alphabet for the style that is being used.

The slant of letters must be kept uniform. For this drawing course, the slant used shall be 60 degrees to the horizontal. That the student may develop a conception of a 60 degree slant, and to provide a guide that does not interfere with freehand construction, the T-square and 60 degree triangle should be used as shown in Figure 66. The pencil lines are <u>not</u> drawn along the triangle but rather about ¼ inch to the left of it. By using these mechanical assistances, the proper slant and a uniform slant will be maintained, muscular control required for freehand lettering will be developed, and the eye will be trained to "see" a 60 degree slant. The T-square should be placed about one and one-half inches below the line of lettering to made and the triangle moved along with the tips of the fingers of the left hand. This leaves the right hand entirely free.

The Study of Letter Spacing

In ordinary reading we recognize a word by the group of letters that make the word. For this reason you will notice that on a printed page the letters of each word are grouped together. To make a word look like one group rather than two or more groups it is necessary to make the <u>apparent</u> space between letters equal. If the letters were

made with the spaces exactly equal they would not appear equal. Figure 67 illustrates the difference between exact spacing and apparent spacing. To assist in making the spaces apparently equal the following will be found helpful.

The alphabet can be divided into two groups of letters, those with closed sides and those with open sides; that is, those letters whose sides fill out or nearly fill out the full width of the letter space, which are: H M N O D G R B S U Q, the first side of F E L K C P and the back of J; and those letters who sides do not fill out the full width of the letter space, which are: A V W Y X Z T, the backs of F E L K C P and the front of J. The first group will hereafter be called "closed" letters and the second group "open" letters. With these two groups it is possible to make three combinations: (1) When two closed letters come together, (2) when two open letters come together, and (3) when an open letter and a closed letter come together.

The space between the same two letters will not always be the same, but depends upon the size of lettering being made and upon the space into which they must fit. If the lettering does not need to be limited in length, good spacing can be secured by observing the following:

(a) Make the space between two closed letters equal to three-eighths of the letter height.

(b) Make the space between an open and a closed letter

equal to two-eighths of the letter height.

(c) Make the space between two open letters equal to one-eighth of the letter height.

(d) Make the spaces for the letter I one-eighth of the height more than the above rules would require.

(e) In the combination of such letters as L T and T A where the apparent space is very large it will be necessary to make the spacing smaller than rule (c) would indicate.

An easy way to remember these rules is by means of a simple diagram. Let a straight line (l) represent a closed letter and let a curved line (() represent an open letter. Then we have the three combinations that would be found in lettering, ll, (), and l) or (l. If we now mark between these symbols the spaces each such combination requires the diagram is complete and gives a short method of showing the three principal rules of spacing, thus: 131, (1), and 12) or (21.

Space between Words and Sentences

The space between the words of a sentence should be equal to that occupied by a letter and its spaces, or said in another way, the words of a sentence should be spaced so that a letter could be placed between the two words leaving the normal spacing each side of this letter. This spacing is illustrated in Figure 68. The space between two sentences should be equal to that occupied by three

letters with their spaces. If the rules for the spacing of letters in a word and the spacing of words are followed, the result will give a grouping of letters in the word that will be as easily read as a printed page.

The Width of Letters

The width of all letters of the same height are not equal but vary more or less so that they will appear in balance with the other letters. The following will greatly assist the beginner in determining the correct width to use so that the letters will have good proportion. Make all letters three-fourths as wide as they are high with these exceptions: A, which is about four-fifths as wide as it is high; M, whose width should be equal to the height; W, with a width equal to six-fifths its height; and I, which should be a single line. The width of letters may be slightly extended or contracted to make the lettering fit a given space, but the relationship of width of the various letters must be maintained.

Lettering Exercises

To assist in learning the shapes of letters the alphabet has been divided into five groups, each group containing those letters having similar construction. Each group will be practiced separately.

Cut a sheet of drawing paper so as to make six small pieces about four inches by two and one-half inches. Fasten

one of the small pieces on the drawing board with the bottom of the paper lined up with the T-square and held in position by a thumb tack at each of the left hand corners. To insure making the tops and bottoms of the letters even, the draftsman must always draw guide lines; one for the tops and one for the bottoms of the letters. These lines must be made very light so that they will erase easily and also so that they will not interfere with the forming of the tops and bottoms of the letters. For the exercise sheet the guide lines will be made one-eighth of an inch apart with one-eighth of an inch between each set of guide lines. The distance between lines of print is usually equal to the height of letter being made.

While the hardness or grade of pencil to use will depend upon the paper being worked upon, as a general rule a pencil three or four grades softer than the drawing pencil being used on that paper will be the best. A 1H pencil is usually satisfactory. The pencil should be sharpened similarly to the drawing pencil, making the lead about ¼ of an inch long. Keep the pencil in good condition by occasionally rubbing on the piece of sand paper.

Letters I, H, T, F, E, L

This group of letters has only 60 degree and horizontal lines. The 60 degree lines should be drawn from the top downward or toward the worker. It will be noticed that

this is just the opposite of the way a mechanical drawn line should be made. The horizontal lines should be drawn from the left toward the right. Hold the T-square and 60 degree triangle as already explained and as illustrated in Figure 66. Construct four letters of each kind starting with the letter I. Make each letter two spaces high, this being one-fourth", and leave two spaces, or one-fourth", between the lines of lettering. Make each letter the correct width and make the spacing between them as given in the preceding rules for spacing. The lines that determine the width of a letter should be drawn first to insure the correct width. After these large letters have been completed, print the whole group in the order as given at the top of this paragraph. Repeat this group until the first sheet is filled. Make the letters only one space high or 1/8". Observe the rules for width and spacing between letters.

Letters K, M, N, X, Z.

Place a second sheet of paper on the drawing board and prepare guide lines as for the first exercise. In this group are found slanting lines that do not follow the 60 degree slant. For the letters K, N, X, Z, draw very light lines at 60 degrees the correct distance apart for the fronts and backs of these letters and connect the necessary points, freehand, to form the letters. The outside lines of the letter M are made first, then select the

middle point on the base line between these outside lines and connect this point with the tops of the side lines. Follow the rules for direction of stroke, width of letters and spacing of letters. Make each letter four times, two spaces high. Then make the group one space high in the order given at the top of the paragraph. Repeat this group until the sheet is filled the same as for the first group of letters.

Letters A, V, W, Y.

The beginner is more apt to form these letters wrong than in any other group, but will have no trouble if the directions are carefully followed. Place the third sheet of paper with the proper guide lines on the drawing board. For the letters V and Y small dots should be placed on the top guide line marking off the correct width for each of these letters. For the letter A the two dots should be placed on the bottom guide line. Now estimate the midpoint between each set of dots and make another dot on the guide line. Through this last dot draw a line at 60 degrees using the method for making 60 degree lines as in the other letters. The remaining lines for A, V, and Y can now be drawn. The cross line for A should be two-thirds of the height from the top. For the letter W select the mid-point and then select the midpoint on each half. Through the latter point draw a 60 degree line and connect the lower

extremity of this line with the top points. In order that the whole letter may appear to be slanting at 60 degrees, the center line must be given this slant. Do not make the mistake of slanting one of the sides of any of this group at 60 degrees. Make each letter four times and then follow the group order as on the preceding sheets.

Letters O, Q, C, G, D, J, U.

Prepare the fourth sheet of paper. It should be noticed that the curve of the sides of these letters are not half circles but rather more of an ellipse. Remember that the center of the letter must be made at the 60 degree slant. The straight sides of the letters D, J, and U should be drawn before the curved part. Start at the top and middle and stroke toward the bottom middle, thus making the letter O in two strokes. In small lettering C and G may be made in one stroke, but for large letters it will be necessary to form them with three strokes. The back of D may be made with one stroke. Proceed with the exercise as on the preceding sheets, observing all the rules.

Letters B, P, R, S.

Prepare the fifth piece of exercise paper. The letter H should first be formed for each of these letters to insure the proper width and middle division. Each curve of the B is made in one stroke. The top of the P, R, and all of S are each made in one stroke. Be sure to make the

backs of both the curves on the B come to a 60 degree line. The bottom point of the leg of the R must also be brought in a 60 degree line with the back of the curve. Complete this last exercise sheet as in the preceding exercises.

Lettering the Plates.

After making all the lettering exercises, the drawing for the first plate should be fastened to the drawing board as when drawing. The space provided at the bottom of the sheet for the name plate or "card" as it is sometimes called, will be the first part to be lettered. The amount of space given to a name plate and the information it should contain varies considerably among different drafting offices. A copy of the name plate used by one large concern is shown in Figure 69. The name plate we shall use, together with the necessary dimensions, is shown in Figure 70. Proceed by steps in the following manner:

First: Draw in pencil the lines which make the form of the name plate.

Second: In very light pencil lines draw the guide lines for the lettering.

Third: With the 1H pencil carefully pencil in the large lettering using the mechanical guides the same as when doing the lettering exercises. Follow all the rules for spacing of letters and words. Shape each letter slowly and carefully. The space at the right end of the name

plate which is usually used for the part number in commercial drawings, on our drawings will be used for the plate number.

Fourth: After completing the large letters, the small lettering may be made.

The scale for plate I shall be, "scale full size." When the drawing is made one-half the actual size, the scale shall then be written, "scare half size." When scales smaller than half size are used, they should be written in the following manner: "scale- 3" = 1' - 0" ".

The "kind of material" should not be written in but only give in that space the name or initials of the material of which the object is to be made. The following may be used for this purpose:

Cast iron ----------	C. I.
Wrought iron -------	W. I.
Cold rolled steel --	C. R. S.
Brass -------------	Brass
Machine steel ------	M. S.
Tool steel ---------	T. S.
Babbitt -----------	babbitt
Cast steel ---------	C. S.
Wrought steel ------	W. S.

The last item on this line "Number required" means the number of such parts as are shown on the drawing as will be necessary to make one unit of the whole job that is being drawn.

On metal objects which are made by casting and then being machined to the desired size and finish, it is neo-

essary that sufficient additional metal be allowed on such surfaces as are to be machined, smoothed or surfaced so that the finished job will be the size desired. The work of planning for such allowances falls on the pattern maker, but the draftsman must show on his drawing where the surfaces are that will require finish allowance. The usual way to show that a surface is to be finished is to place a small letter "f" on the line and at right angles to the line that indicates the edge view of the surface to be finished.

Each surface to be finished shall be marked only once in this way. To indicate that a hole is to be a machined hole and not a cast hole, one of the following words are placed in line with the dimension for that hole: drill, bore, or turned. "Drill" is used for holes that are to be made with a machine drill; "bore" is used for larger holed that must be made with the boring bar either in the lathe or the drill press; "turn" is used for the largest holes that are turned on the lathe. This term is more frequently used to indicate that an outside round surface is to be finished by turning in the lathe. The word "spot face" is used when only a small part of a surface is to be finished, such as would be required for a nut seat. In some shops the amount to be allowed for finish is indicated on the drawing by placing one, two, or three "f's" in a group,

each "f" meaning that one-eighth of an inch is to be allowed. Thus three "f's" would require an allowance of three-eighths of an inch. As all of our drawings are of small or medium size, it will be necessary to use only one "f" at each place. When an object is to be finished on all surfaces, the "f's" are omitted, and the words "finish all over" are placed in a convenient place on the drawing. Sometimes these words are abbreviated and only the letters "F. A. O." are used.

When information is needed on a drawing that cannot go in the name plate or as a dimension, it may be put in some convenient place on the paper, but off of the drawing proper, in the form of a note and to be preceded by the word "note". If the information needed is not too lengthy, it may be placed just off the drawing proper but near the point to which it refers and connected to that point with a freehand arrow. Both of these ways are shown in Figure 71.

The information required on each drawing can be obtained from the following outline:

Plate 1 Iron Block
Scale - full size
Material - cast iron
Number required - one
Finish all over

Plate 2 Clamp Block
Scale - full size
Material - cast iron

Number required - one
Finish - only the notches on the ends

Plate 3 V Block
Scale - full size
Material - cast iron
Number required - one
Finish all over.

Plate 4 Adjusting Lever
Scale - full size
Material - cast iron
Number required - one
Finish - indicated on the sketch

Plate 5 Brake Quadrant
Scale - full size
Material - machine steel
Number required - two
Finish - indicated on the sketch

Plate 6 Rocker Arm
Scale - full size
Material - machine steel
Number required - eight
Finish - indicated on the sketch

Plate 7 Cone Pulley
Scale - full size
Material - cast iron
Number required - two
Finish - all outside surfaces
Notes - about webs as on the sketch

Plate 8 Bracket
Scale - full size
Material - cast iron
Number required - one
Finish - top surface of bosses and top face of right end

Plate 9 Bolts and Threads
Scale - give the scale used for each of the parts at the bottom of each part
Material - the material for each part should be marked beside or under the scale for each part.
Number required and finish will not be indicated.

Notes - all information on thread shapes and sizes

Plate 10 Eccentric Strap
Scale - full size
Material - cast iron
Number required - one
Finish - outside side surfaces, and flat surfaces of the three lugs
Notes - all information on drill, tap, and thread sizes.

When all the lettering has been placed on all the drawings in pencil, they should then be "inked in". The ball point pen will be used for the larger letters in the name plate. Prepare the pen and use it as directed under "Dimensioning". All other lettering on the drawing shall be inked with the second weight pen #621. Remember the quotation at the beginning of "lettering" and do this work with the greatest of care. Go very slowly - do not work for speed. Begin with the first plate and go through the ten in their consecutive order.

The drawing should now be cleaned by rubbing the entire surface with art gum. Remove all indications of pencil marks, dirt, finger prints, erasures, or other causes of detracting from the appearance of the drawing. This set of drawings is now complete.

CHAPTER VI

DIVISION OF ADVANCED WORK

Plate XI
Assembly Drawing (Float Valve)

I. Purpose:

To provide practice in reading drawings.

To illustrate the system of detailing a single project.

To make an assembly drawing.

To illustrate a system of dimensions from the center line.

II. Tools required:

Drawing board, T-square, triangles, scale, set of instruments, limb protractor (optional).

III. Supplies required:

One double sheet drawing paper, penciling and inking material.

IV. Instructions:

1. Place the drawing paper on the board with the long dimension in a vertical position and draw a border ling 12½" x 19".

2. An assembly drawing serves three purposes. First, by following the dimensions given on the detail sheets it will test whether these parts are of the proper size to fit in the position for which they were designed. Second, the assembly drawing is used in the assembly department of the shop to show where and how the various parts are to be

assembled. Third, the assembly drawing is the nearest to a pictorial showing of the object and is sometimes used to show how the finished object will appear. An assembly drawing is illustrated in Figure 72a and Figure 72b. Figure 72c illustrates an assembly drawing together with its details.

3. There should be two views in this assembly drawing, a front view, and a top view. The usual method of figuring spacing should be used except that the end of the handle on the right side of the drawing may be made to almost touch the right border line, the extra space being allowed on the left side of the drawing. This is done to bring the apparent mass of the drawing nearer the center of the sheet. As in other circular drawings, the center lines should be made first.

4. In an assembly drawing no invisible edges are indicated unless that is necessary to show where or how some part is placed. In this drawing no invisible edges are required.

5. Each part on an assembly drawing shall be given the same number as found on the detail sheet for that part. Some definite system for arrangement of numbers should be used. If possible, the numbers should not be placed on the drawing of the part but rather to one side and connected to the part by an arrow. Sometimes letters or combina-

tions of letters and numbers are used to designate the parts.

6. It has been stated that one of the purposes of an assembly drawing is to show how the finished object will appear. To assist in this objective, shade lines are frequently placed on the edge views of circular surfaces. Such lines should be of very light weight placed rather close together at the outer edges of the curve and gradually becoming farther apart toward the center. There should be a blank space at the center of the curve. The shading lines may or may not be put on.

7. No dimensions or finish marks shall be placed on the assembly drawing.

8. It should be noted on the detail drawing of the handle that a system of dimensioningis used that has not appeared before. In order that the patternmaker may secure a desired shape of curve that cannot be drawn with the compass, it is necessary to give the dimensions for the location of a series of points through which the desired curve may be drawn. The "French" or "irregular" curve is used to connect the series of located points. In using the irregular curve see that it connects at least three points each time. Also make each new part of the curve overlap the previous part by the distance between one set of points. This is done that the finished curve may look like one

continuous line rather than a series of short curves.

Section Assembly Drawing
Plate 12 (Steam Thrust)

I. Purpose:

To make a section assembly drawing.

To use a proportional scale.

II. Tools required:

Complete set of drawing instruments.

III. Materials required:

One double sheet of drawing paper, pencilling and inking materials.

IV. Instructions:

1. An assembly drawing which shows only the outside of the object such as made for the Float Valve is not satisfactory when a number of parts are enclosed within the larger piece. For this reason, it is often necessary to make "section assembly drawings", that is, a section view through the assembled object.

2. The drawing to be made for this plate will be similar to that shown in Figure 73. The dimensions for this drawing are to be taken from the detailed drawings of the Steam Thrust as provided in Plate 12. (11 sheets.) A copy of the drawing to be made is also provided for this plate.

3. It should be noticed that the detail drawings for the Steam Thrust are made to different scales. This makes

it hard to form a mental picture of the complete object. It will therefore be necessary to work exactly from the dimensions provided. By a study of the dimensions it will be seen that it is impossible to make the assembly drawing "full size" on a double sheet of drawing paper. The next possible scale would be "half size"; this also is too large. The next possible scale would be "one fourth size" or 3" equals 1' - 0". A little arithmetic will soon show that the drawing can be made to this scale on the size paper being used.

4. The crosshatching of the separate pieces in the section assembly drawing should be planned so that adjoining pieces shall have their crosshatching lines slanting in opposite directions. This assists greatly in distinguishing the separate pieces.

5. The drawing shall contain no dimensions, but each part shall be marked with the number found in the name plate of the detail drawing for that part.

6. In a drawing such as this which contains so many different pieces and which are so closely connected, it is very essential that a good distinction be made in the weight of lines used for the visible edges and that used for the crosshatching lines when inking the drawing. Make an effort to see that the crosshatching lines are evenly spaced.

To use a proportional scale.

A drawing made to the scale 3" equals 1' -" means that a line drawn three inches long on the drawing represents one foot on the actual object. The 3" on the scale corresponds to 12" on the object. The 3" scale is redivided, first into 12 parts, each part representing 1". Each such inch is then redivided into the common divisions of an inch, the smallest division on the 3" scale representing 1/8 inch of object. The remainder of the 12" scale is only divided into 3" spaces each, being 12 inches on the object.

If an object 9" long is to be drawn to the 3" scale, it is not necessary to find 1/4 of 9 but simply to mark off from the zero point on the 3" scale the 9" mark on that scale. When a dimension is over one foot, it will be necessary to express it in feet and inches; thus, 20" should be read on the scale as 1' - 8". Figure 74 shows how to mark off this dimension.

Detailing

Plate 13 (Timber Pulley)

I. Purpose:

To make separate detailed working drawings from an assembled picture drawing.

To show how to make a tracing.

II. Tools required:

Complete drafting set.

III. Materials required:

7 single sheets drawing paper.

7 sheets training paper or training cloth.

Pencilling and inking materials.

IV. Instructions:

1. In the drawings made up to Plate 13, the procedure or order of making drawings as practiced in most commercial drafting rooms has not been followed, but beginning with this plate such shall be the objective.

2. The commercial procedure usually is to first, make the pencil drawing on paper; second, put on the dimensions; third, put on lettering and notes; (sometimes the lettering and notes are only written freehand on the pencil drawing;) fourth, make a tracing of the pencil drawing directly in ink, containing the dimensions with notes and lettering; (if the notes were written freehand on the pencil drawing then they should be printed in pencil on the tracing before inking; if, however, they were printed on the pencil drawing then they may be inked on the tracing without repencilling;) fifth, make the blue print from the tracing.

3. The picture drawing of the Timber Dolley shows such a dolley with all its parts placed together in their proper position. It is the student's job to take this apart in

his imagination and to make complete working drawings of each part shown as required to make the Timber Dolley. Each drawing must be entirely complete in itself or contain all information that would be needed by the workman to make it.

4. The usual commercial practice of placing the drawing of only one object on each sheet should be observed. The student will need to determine for himself how many views of each object are required. A half sheet, that is, one-half of a 10 x 13½ is the smallest unit sheet that may be used for any one object. Do not cut the single sheet, but rather divide the sheet with a pencil line and make a separate drawing on each half.

5. The scale to be used for each object will need to be determined. It may be more convenient to use a different scale for the different parts. As each drawing is complete in itself it would be correct, if so desired, to do so. It is economy in time and in material to draw large simple objects to a reduced scale. It is probably best to draw small objects full size.

6. An article that is a standard commercial product and that is procurable in the open market is seldom made separately for single jobs. It is therefore not necessary to make drawings of such articles if they form part of the whole job. They are usually only listed in the material

list or specifications. Several such articles appear in the Timber Dolley, the bolts, nuts and washers for the pillow blocks, and the nuts and washers for the tie rods. These need not be drawn.

7. The pencil drawings for all of the required parts for the Timber Dolley should be made before any of the tracings are made. This is done so that if necessary to make any changes in the drawings or dimensions as the various parts are developed they may be made with comparative ease. Check the dimensions for each part and see that they fit with the other parts or in the space provided for that part.

8. Drawings in a shop are usually known by their number or letter. Each separate drawing should be provided with such a means of identification. It is suggested that the initials of the complete object be used as a serial number and that the individual pieces be designated by consecutive numbers. For example, the letters T.D. will serve as serial numbers for the Timber Dolley. These letters to be followed by the numbers 1, 2, 3, 4, etc., using one number for each part. The first part to be drawn would, therefore, be numbered "TD1". The last right hand space in the name plate is provided for the number.

9. It is necessary to make a complete and separate drawing for each of the following parts:

	Name of part	Material	Number Required
1.	Side timber	wood	2
2.	End timber	wood	2
3.	Axle	cold rolled steel	1
4.	Pillow block	cast iron	2
5.	Bushing	babbitt	2
6.	Tie rod	wrought iron	2
7.	Roller	cast iron	1

To Make a Tracing

Making the tracing is the final piece of work of the draftsman. The quality of the work on the tracing, the accuracy of the drawing, the neatness of the lettering, and the correctness of the dimensions will show here as the evidence of the draftsman's ability. All work on a tracing should be done with the greatest care. The quality, weight, or width of line used in inking should be carefully selected that the correct line value may assist in making the drawing clear.

Tracings may be made either on tracing paper or on tracing cloth. Tracing paper is made of thin paper of good quality and treated so as to make it transparent. It will not stand much, if any, erasing, and is liable to be torn if handled to any great extent. For these reasons tracing paper should be used only for simple drawings that probably will not require many corrections or from which only a few prints are to be taken. The tracing paper is, however, very much cheaper than tracing cloth, and for this reason is usable for many purposes.

Tracing cloth is made from a thin, fine quality cloth which is treated with a starch preparation so as to make it transparent. If a tracing is to contain very much work, or if many prints are to be taken from the tracing, it should then be made on tracing cloth. Tracing cloth costs about ten times as much as tracing paper. Most commercial draftings are made on tracing cloth. The student may use either paper or cloth for the tracings being made, though it is suggested that one group of drawings be traced on paper and that the second be traced on cloth so that the experience of working on both may be had. In tracing on the cloth the work should be done on the dull side.

Helpful Suggestions for Tracing

Have the pencil drawing exactly lined up with the T-square before covering with the tracing cloth.

Fasten the cloth with thumb tacks placing them as follows: Place two or three thumb tacks in the top left hand corner and stretch the cloth from the lower right hand corner until a ridge appears across the cloth, fasten this corner while thus stretched. Brushing the cloth from the center toward the remaining corners will make it lie tight to the paper. Do not leave thumb tacks in the paper under the tracing cloth. They prevent the cloth lying tight to the paper. The tack in each corner of the paper should be removed when the tack for the tracing at that corner is

is being placed. A smooth, tight, tracing is greatly to be desired. It is much easier to work with and assists in greater accuracy.

Both tracing cloth and tracing paper should be dusted with chalk or talcum powder to cover over the oily or greasy surface so that the ink will "take" well. Excess amounts of chalk or talcum should be brushed off with a cloth or fine brush.

The pencil eraser should be used to remove ink from tracing cloth. If the ink eraser is used it will roughen the surface and make it unfit for further work.

A soft pencil such as the 1H should be used if any pencil work is to be done on the tracing.

A tracing may be cleaned and pencil marks removed from the surface by wiping with a cloth dampened in gasoline or benzine.

Pencil guide lines should be drawn for all lettering on the tracing even though such lines were drawn on the pencil drawing.

Do not remove a tracing until it is complete as it is almost impossible to replace it as it was at first.

Moisture on the surface of tracing cloth will leave a spot that cannot be removed and that will show on the blue print. Do not touch the tracing with moist hands. A sneeze or cough on a tracing may ruin it.

Plate 14 (Connecting Rod)

I. Purpose:

To make detailed working drawings from a dimensioned assembly drawing.

To show how to make blueprints.

II. Tools required:

Complete set of drawing instruments.

III. Materials required:

Four single sheets drawing paper, four single sheets of tracing paper or tracing cloth, penciling and inking materials.

IV. Instructions:

1. The dimensioned assembly drawing of the connecting rod shows such a rod with all its parts placed together in their proper position. It is the student's job to take this apart in his imagination and to make complete working drawings of each different part to be found thereon.

2. The detail drawing for each different part must be complete and contain all information required by the workman to make that part:

a. dimensions.

b. finish marks.

c. name of material of which it is to be made.

d. number of these parts required for one complete connecting rod.

e. the standard name plate.

3. The same commercial practice shall be followed in drawing this plate as used in the preceding one, i.e.: the drawing of each part shall be on separate sheets, no sheet shall be less than one-half a standard sheet, only pencil the drawings on the paper, trace the drawings in ink.

4. If two parts are to be drawn on a single sheet the paper should be turned with the long direction of the paper in a vertical position and divided in the middle by a horizontal line. Space must be allowed on the bottom edge of each part (this is the 9" edge) for the standard name plate.

5. Make as few views of each part as may be needed to show all information; no part to have less than two views. All drawings should be full size. The following parts are required:

Name of Part	Material	Number Required
1. Main rod	special steel	1
2. Cap	special steel	1
3. Connecting rod bushing	babbitt	2
4. Wrist pin bushing	brass	1
5. Bolt	machine steel	2
6. Castle nut	machine steel	2
7. Split washer	spring steel	2

6. Provide a serial and individual number in the name plate for each part. Information relative to the castle nut and to the number of threads per inch on the bolt may be obtained from the table "Castle Nut Proportions". The

drawing of a split washer is shown in Figure 76. It should be noted that the thread on the bolt and nut is the S.A.E. standard.

To Make Blueprints

For most purposes, several copies of a drawing are required which if made separately would be very expensive. It is for the purpose of producing a number of copies that a tracing is made. The additional copies are made in blueprint form from the tracing. To make a blueprint, it is necessary to have a printing frame, fresh water in some form of tray at least as large as the print to be made, and blueprint paper. The print is made as follows:

Open the printing frame and turn with the glass side down, lay the tracing on the inside of the glass with the ink side against the glass. Cut a piece of blueprint paper slightly larger than the tracing and lay it on top of the tracing with the coated side against the tracing. Cover with the pad and clamp on the backing boards. Turn the front of the frame perpendicular to the direct rays of the sun. The time required for exposure will depend upon the kind and age of paper being used, the time of day and brightness of the sun. Fast paper will require from 30 seconds to two or three minutes in bright sunlight. A print may be made in daylight but not in direct sunlight by exposing from ten minutes to an hour. The time of

exposure in all cases will need to be found by experimenting. After exposure the print should be placed in running water for five minutes to be thoroughly washed; if washed for less time it is liable to fade. Many blueprints that have been over-exposed can be brought out and saved by washing the surface with a dilute solution of potassium bicromate. A blueprint that has been "fixed" with this chemical will need to be washed more than usual. After washing, the print should be hung over a stick, string, or wire and allowed to dry. The drying may be done more rapidly by placing the print on a hot radiator or suspending the print over heat in some form. Do not handle the tracings with wet or moist hands or allow any water to be dropped on the tracing.

Most commercial blueprinting is done on blueprinting machines. The principle of blueprinting by machine is the same as that of hand and sunlight except that the light in the machine is supplied by electricity.

DIMENSIONS FOR S.A.E. CASTLE NUTS

Diameter of Bolt	Threads per inch	A	B	C	D
1/4	28	3/8	5/64	3/32	9/32
5/16	24	1/2	5/64	3/32	21/64
3/8	24	9/16	1/8	1/8	13/32
7/16	20	11/16	1/8	1/8	29/64
1/2	20	3/4	1/8	5/16	9/16
9/16	18	7/8	5/32	5/16	39/64
5/8	18	15/16	5/32	1/4	23/32
11/16	16	1	5/32	1/4	49/64
3/4	16	1 1/8	5/32	1/4	13/16
7/8	14	1 1/4	5/32	1/4	29/32
1	14	1 7/16	5/32	1/4	1

CHAPTER VII

DIVISION OF TESTING

TRUE-FALSE STATEMENTS

The true-false question is a quick method of testing one's self or of testing another for information on a given subject. The following questions are all answered in the text under the heading that precedes each group. For the purpose of rapid checking of the answers for these questions a list of answers has been placed at the end of the entire group.

To use the true-false questions the person answering need only to read the question and then write the letters "T" or "F" (these being the initial letters for true and false) or the complete word "true" or "false" before the question. Place the word "true" if you think the statement is true, and place the word "false" if you think the statement is false. Do not leave any question unanswered, as in scoring all unanswered questions are counted in with the wrongs. The usual method of scoring is to subtract the wrongs from the rights, the result being the score.

It is suggested that the tests be taken upon the completion of each group as listed below and not waiting until the material of several groups have been studied. If the numbers as found on the group of questions to be answered are written on a small piece of paper and the answers "true" or "false" placed after these numbers it will save marking in

the book and will also make checking easier.

The T-square:

1. The T-square should be used on the left edge of the drawing board.
2. The T-square may sometimes be used as a straight edge to connect two distant points.
3. The T-square should be moved with the right hand.
4. A nick in the edge of the T-square will show in the lines drawn along that edge.
5. The T-square is used when drawing vertical lines.
6. Lines should be drawn only along the top edge of the T-square.

The triangles:

7. An angle is a distance that is measured in feet and inches.
8. Two straight lines coming together form an angle.
9. Each triangle contains four angles.
10. The angular distance aroun1 a circle is 360 degrees.
11. The angles of one triangle are 30, 45, and 90 degrees.
12. The angles of another triangle are 45, 45, and 90 degrees.
13. The triangle is used against the lower edge of the T-square.
14. The triangle should be under the hand that is drawing the line.

15. The triangle is used to draw horizontal lines.

16. The triangle is used to draw vertical lines.

17. The triangle is used to draw slanting lines.

The scale.

18. The scale is to be used to measure with only.

19. All measurements should begin at the very end of the scale.

20. When measuring from a line the scale must be held perpendicular to that line.

The pencil.

21. A 6H pencil is harder than a 1H pencil.

22. Line drawing should be done with the 1H pencil.

23. A short point is desirable as it will not break so easily.

24. The lead of the pencil should be sharpened with a knife.

25. The point of a newly sharpened pencil should be about three-eighths of an inch long.

26. The pencil should be used with sufficient pressure to make an indentation in the paper.

Making the border lines.

27. The paper should be placed near the left edge of the drawing board.

28. Thumb tacks should not be pressed in hard as this will make them hard to remove.

29. Horizontal lines should be drawn toward the right.

30. Vertical lines should be drawn upward, away from the worker.

31. Two points are necessary to draw a horizontal line with the drawing tools.

32. The dimensions for the standard border line are 9½ x 12.

Position of views.

33. In a photograph all parts are not their true size in relation to other parts in that picture.

34. In mechanical drawing all parts are drawn their exact size in relation to other parts in that drawing.

35. In a mechanical drawing one view will show all facts necessary to make that object.

36. The name of the most common views drawn are top, bottom, and side.

37. The position of a view in relation to the other views determines the name of that view.

38. All points in the side view are in a horizontal line with their respective points in the front view.

39. The top and side views are always the same width.

40. A visible edge is to be represented by a broken line.

Spacing of views.

41. It is necessary to space the views of a drawing that the drawing may appear well.

42. The space on all four sides of the drawing should be equal.

43. An apparently equal spacing is desirable.

Plate 1. (Iron Block)

44. A dot should be placed at each point where lines intersect.

45. "Blocking in" insures the views being in their correct position in relation to each other.

46. The lines of the pencil drawing should not cross each other at the corners.

47. The thickness of the bottom piece in the front and side views will need to be measured separately.

48. All the edges in this drawing are visible edges.

49. The lines that run over at the corners of the object should be erased as they will be of no later value.

Plate 2. (Clamp Block)

50. The "Blocking in" method is used in drawing the outline of the Clamp Block.

51. Each view should be drawn completely before starting the next view.

52. The new kind o line found on this drawing is called a "dotted" line.

53. A dotted line represents an imaginery edge.

54. The length of the dots and spaces in a dotted line are to be determined by the student.

55. A good length dot to use is about one fourth of an inch.

56. The dots of a dotted line should never touch the terminating lines.

57. When dotted lines form a corner they should meet.

58. When dotted lines cross each other there should be a space left at the point of crossing.

59. Well made dotted lines make a drawing easier to read.

Plate 3. (V Block)

60. Two intersecting lines locate a point more exactly than does a dot.

61. To draw a line at 45 degrees to a horizontal, it is necessary to locate two points in that line.

62. A slanting line forms an edge when it meets a horizontal line.

63. Projection is the method of locating a point or line in a second view without the use of the scale if its location in the first view is known.

64. Horizontal projection is done with a triangle.

65. Vertical projection is done with the T-square only.

Plate 4. (Adjusting Lever)

66. Three views are required for all objects.

67. The first lines to be drawn for a circular object is the center lines for the circle.

68. A center line does not show any part of the object.

69. A small space should be left where two center lines meet.

70. All center lines are straight lines.

71. A line that is tangent to a circle enters the circle at the point of tangency.

72. Center lines must be drawn for every circle.

The Compass.

73. The lead of a compass should be sharpened round.

74. A tight friction joint makes it easy to accurately adjust the compass.

75. If the line made by the compass is not dark enough, a little more pressure should be exerted.

76. Circles should be drawn in one direction only, usually clockwise.

77. The bow compass should be used for circles of less than one inch in radius.

Plate 5. (Brake Quadrant)

78. In projection, if the T-square or triangle forms a tangent to the side of a circle in the front view, there should be a line at the position of tangency

in the side or top view as the case may be.

79. A circle or arc of a circle cannot be drawn tangent to both a straight line and a circle at the same time.

Plate 6. (Rocker Arm)

80. A fillet is a drafting instrument used in drawing small circles or arcs.

81. A fillet assists in molding the pattern.

82. Guessing at the center for a fillet is a satisfactory method for the beginning draftsman.

83. When a fillet joins a flat surface it forms an edge which should be represented with a line.

84. The intersection of two fillets that are at right angles to each other forms an edge which is at 45 degrees to the direction of each of the fillets.

Plate 7. (Cone Pulley)

85. In drawing a circle the distance between the points of the compass is the diameter of the circle.

86. In drawing circular objects one of the views is usually a cross-section view.

87. One can tell a cross-section view as it is always crosshatched.

88. Crosshatching is put on only to show that the object is cut in two.

89. Crosshatching is put on only that part of the object that would be actually cut if a section were made of the object.

90. If a section is made thru a rib the rib is not crosshatched.

91. The size keyway to be used is determined by the size of the shaft.

92. The depth of a keyway is to be measured on the center line of the shaft.

Plate 8. (Bracket)

93. An object that is not perpendicular to the line of sight of the observer does not show in its true shape.

94. An auxiliary view is one that does not come directly above, below, or to the side of the front view.

95. An auxiliary view is drawn at a slant of 45 degrees to the surface to be shown.

96. The whole of an object should be shown in the auxiliary view.

97. When an auxiliary view is to be made on a drawing it requires judgment rather than figuring to determine the location of the views.

Plate 9. (Bolts and Threads)

98. The pitch of a thread is the distance between the points of two adjacent threads.

99. The lead of a screw is always equal to the pitch.

100. The root diameter of a screw determines the size tap drill to be used.

101. The head and nut of a bolt are of equal thickness.

102. On a single thread the slant of the thread is equal to one-half of the pitch.

103. The distance between the light lines on a drawing of a thread is equal to the pitch.

104. It makes no difference which way the slant of the thread is shown on the drawing of a bolt.

105. An object is always drawn its full size.

106. The full dimension is always written on the drawing.

107. The exact number of threads per inch must always be drawn.

Plate 10.

108. The first lines to draw for a circular object is a square to enclose the circle.

109. In a section view of a vertical righthand threaded hole the lines showing the threads will slant upward toward the left.

110. If a hole is to be threaded for a one-half inch bolt, the hole should be drilled one-half inch in diameter.

111. The threads on a threaded hole in a cross-section view slant in the opposite direction to those on a bolt.

Inking.

112. Both the inside and outside of the ruling pen should be kept free from dry ink.

113. Dry ink may be rubbed off the ruling pen with a piece of sand paper.

114. A right hand person should hold the ruling pen in the left hand while filling it with ink.

115. The ruling pen should be filled one-fourth inch with ink.

116. Considereble slant should be given to the ruling pen when drawing a line.

117. Horizontal lines should be drawn from the left toward the right.

118. Vertical lines should be drawn from the top down or toward the worker.

119. In inking vertical lines the triangle should be under the hand that holds the ruling pen.

120. Squeezing the nibs of the pen together with the set screw will give the pen a better shape.

121. The set screw on the ruling pen should be adjusted several times while inking one weight of line on each drawing.

122. It is best to use a blotter on each line so that it will not be necessary to wait for the ink to dry.

123. If a pencil eraser is used to clean up an inked drawing it will make the ink lines pale.

124. Small particles of eraser or dust will not interfere with the ruling pen as the pen will push them to one side.

125. There are only two weights of lines used in inking a drawing.

126. A good method to use when inking horizontal lines is to start at the bottom and work toward the top.

127. Ink lines should meet exactly at the corners but must not cross.

128. A good method to use in drawing vertical lines is to start at the left and work toward the right.

129. Only the ink eraser should be used in erasing an ink blot.

130. The weight of a dotted line is much less than that of a solid line.

131. The order of inking for dotted lines is different from that for visible edge lines.

132. Drawing an ink line to or across a wet ink line is liable to make a blot.

133. Visible edge circles should be the first lines on a drawing to be inked in.

134. A space should be left in a center line when it crosses another line.

135. A center line is the same weight as a dotted line.

136. When a large circle is being inked it is necessary to bend the joint in the compass so as to make the nibs perpendicular to the paper.

137. All circular lines should be inked in before inking any of the straight lines.

138. If a line is tangent to a circle one should be able to point out the point of tangency if the drawing is inked in well.

139. Crosshatching lines should be inked the same weight as a center line.

140. The line showing the edge of a section should be inked as a solid line.

141. The lines on a bolt that indicate the root of the thread (this is the shorter lines) should be inked as solid full weight lines.

142. A line which shows a break in an object should be inked as a visible edge line.

143. When threads show in a section view, the lines which indicate the points of the threads (this is the shorter lines) should be inked as solid

full weight lines.

Dimensioning.

144. A good draftsman must have a knowledge of shop processes.

145. An extension line is the line on which the dimension is written.

146. One end of the extension line should touch the object.

147. A dimension line is the line on which the dimension is written.

148. The arrow heads on the ends of the dimension lines should touch the extension line.

149. The extension line should just come to the point of the arrow head which is on the dimension line.

150. A good space to use between the object and the dimension line is one-fourth of an inch.

151. The size of an arrow head should depend upon the amount of space in which the arrow head is to be drawn.

152. Dimensions should be placed between views as much as possible.

153. Short dimensions should be placed in line with each other.

154. Long dimensions should be placed next to the object and the short dimensions on the outside.

155. If possible the dimension should be written on the object.

156. It is good practice to make a dimension number large where there is plenty of space and small where the space is small.

157. All dimensions should read from the bottom of the drawing.

158. The dimensions required by the workman to make the object are the ones to be put on the drawing and not those required by the draftsman in making the drawing.

159. A space need not be left in the dimension line for the dimension if the dimension is a whole fraction.

160. A fraction should be twice as high as a whole number.

161. Each number in a fraction is as high as a single whole number.

162. If the width of an object appears in both the top and side views the dimension for that width should be placed in both places.

163. A space should be left in the dimension line for most dimensions.

164. Dimensions are placed on the drawing to show the shape of the object.

165. Dimensions are placed on the drawing to show the size of the object.

166. A rectangular hole is usually dimensioned on the hole in the view in which the shape of the hole appears.

167. Usually a dimension is not given to a dotted line.

168. If all of the rules of dimensioning are followed exactly there will be no question of where the dimension should be placed.

169. The dimension line for an angle is an arc.

170. A complete circle is usually dimensioned by giving the diameter of that circle.

171. Arcs of circles are usually dimensioned by giving the radius.

172. The location of a circle is determined by giving the dimension to the side of the circle.

173. A small drilled hole should be dimensioned by giving the diameter of the drill to be used in drilling that hole.

174. A radius dimension should have an arrow head at both ends of the radius line.

175. The dimensions for a circle are preferably written on the center lines for that circle.

176. When a number of dimensions are placed one outside of the other the figures should be placed

on alternate sides of the center line.

177. If a dimension is written on a crosshatched surface a space should be left in the crosshatching lines for the figures.

178. The size of a keyway is determined by the length of the shaft.

179. Bolts are usually dimensioned in terms of the bolt diameter.

180. The term L.H. as applied to a thread designates the shape of thread to be used.

Lettering.

181. The name of the kind of lettering used in this course is Single Stroke Drafting Letters.

182. All lettering in this course is to be in caps.

183. The most satisfactory spacing and shaping of letters depends upon a "good eye".

184. The slant of all letters must be kept uniform.

185. The tops and bottoms of letters need not be kept exactly in line.

186. The weight of line used varies with the different letters.

187. The space between letters must be kept uniform.

188. A "closed" letter is one whose side fills out or nearly fills out the full width of the letters space.

189. The letter "V" is a closed letter.

190. Lettering may be divided into three groups; closed, round, and open.

191. A large number of combinations must be learned to be able to determine spacing.

192. The space between two open letters is the smallest space between two letters.

193. The space between and open and a closed letter is less than that between two closed letters.

194. The space between two sentences in the same as that between two closed letters.

195. A space equal to the width of three letters should be left between two words.

196. With a few exceptions, all letters are to be made of equal width.

197. The following three letters are arranged with the widest one first and the narrowest one last; M, W, A.

198. Speed is the most important item for good lettering.

199. Guide lines greatly assist in keeping the tops and bottoms of letters even.

200. The space between two rows of lettering is usually equal to the height of the letters being used.

201. The top and bottom lines of the letter E are of unequal length.

202. The sides of the letter M should be made parallel.

203. The sides of the letter W should be made parallel.

204. The first side of the letter A should slant at 60 degrees.

205. The center line of the letter V should slant at 60 degrees.

206. The letter J should have a cross line at the top.

207. The bottom of the letter R should be as wide as the top.

208. It is easier to letter with a mediumly soft lead pencil than with a hard lead pencil.

209. Under the heading "Kind of material", the letters C.I. stand for cast iron.

210. "Allowance for finish" means the increase in size the pattern maker must give to the pattern over the size the object is to be when completed in the machine shop.

211. "Allowance for finish" may be indicated by marking an X on the edge view of the surface that is to have this allowance.

212. The size of a drawing should not include the allowance for finish but should be the size of the completed job.

213. If an object is to be machines on all of its surfaces these surfaces need not be marked for

finish, another method is used in this case.

214. The letters F.A.S. should be put on a drawing if all surfaces are to have allowance for finish.

215. Finish allowance on circular surfaces may be indicated by the words bore, turn, drill, etc.

True-false Marking

t is used for "true" and f is used for "false"

1 - t	51 - f	101 - f	151 - f	201 - f
2 - t	52 - t	102 - t	152 - t	202 - t
3 - f	53 - f	103 - t	153 - t	203 - f
4 - t	54 - f	104 - f	154 - f	204 - f
5 - f	55 - f	105 - f	155 - t	205 - t
6 - t	56 - f	106 - t	156 - f	206 - f
7 - f	57 - t	107 - f	157 - f	207 - t
8 - t	58 - f	108 - f	158 - t	208 - t
9 - f	59 - t	109 - t	159 - t	209 - t
10 - t	60 - t	110 - f	160 - t	210 - t
11 - f	61 - f	111 - t	161 - f	211 - f
12 - t	62 - t	112 - t	162 - f	212 - t
13 - f	63 - t	113 - f	163 - t	213 - t
14 - t	64 - f	114 - f	164 - f	214 - f
15 - f	65 - f	115 - t	165 - t	215 - t
16 - t	66 - f	116 - f	166 - t	
17 - f	67 - t	117 - t	167 - t	
18 - t	68 - t	118 - f	168 - f	
19 - f	69 - f	119 - t	169 - t	
20 - t	70 - f	120 - f	170 - t	
21 - t	71 - f	121 - f	171 - t	
22 - f	72 - t	122 - f	172 - f	
23 - f	73 - f	123 - t	173 - t	
24 - f	74 - f	124 - f	174 - f	
25 - t	75 - f	125 - f	175 - f	
26 - f	76 - t	126 - f	176 - t	
27 - t	77 - t	127 - t	177 - t	
28 - f	78 - t	128 - t	178 - f	
29 - t	79 - f	129 - f	179 - t	
30 - t	80 - f	130 - t	180 - f	
31 - f	81 - t	131 - f	181 - f	
32 - f	82 - f	132 - t	182 - t	
33 - t	83 - f	133 - t	183 - t	
34 - t	84 - t	134 - f	184 - t	
35 - f	85 - f	135 - f	185 - f	
36 - f	86 - t	136 - t	186 - f	
37 - t	87 - t	137 - f	187 - f	
38 - t	88 - f	138 - f	188 - t	
39 - t	89 - t	139 - t	189 - f	
40 - f	90 - f	140 - f	190 - f	
41 - t	91 - t	141 - t	191 - f	
42 - f	92 - f	142 - t	192 - t	
43 - t	93 - t	143 - t	193 - t	
44 - f	94 - t	144 - t	194 - f	
45 - t	95 - f	145 - f	195 - f	
46 - f	96 - f	146 - f	196 - t	
47 - f	97 - t	147 - t	197 - f	
48 - t	98 - t	148 - t	198 - f	
49 - f	99 - f	149 - f	199 - t	
50 - t	100 - t	150 - f	200 - t	